Global Change and biotechnology

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On behalf of the Netherlands Commission Genetic Modification

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Preface

This project was supported by a steering committee. Schuttelaar & Partners and Wageningen UR would like to thank the members of the steering committee for their constructive and inspirational comments. The members were: Prof. Dr. E.T. Lammerts van Bueren (professor of organic plant breeding and member of COGEM), Dr. P. Osseweijer (doctor in communicating biotechnology and member of COGEM), Drs. I. Haenen (policymaker biotechnology at the ministry of the Environment) and Drs. Ing. R. Mampuys (staff member of COGEM).

Table of contents

Executive summary

Introduction

In the call for proposals 2007, one of the subjects was "Global Change and Biotechnology". Under this heading, de COGEM welcomed proposals for pre-studies on the question to what extent biotechnological solutions to problems of global change are realistic and feasible. Apart from technological problems, issues of social acceptance, global justice and the relations between industrialized and developing countries are also relevant here, the COGEM added.

Approach

The subject was approached in two ways. Schuttelaar & Partners, a consultancy in the field of health and sustainability, has interviewed 16 internationally recognized experts in the fields of global change as well as in the field of biotechnology. Furthermore, Schuttelaar & Partners has set up an internet based discussion on global change and biotechnology in order to involve other stakeholders. Wageningen University and Research Centre (WUR) has done case studies, focusing on causes and solutions for gaps between technological and societal innovation agendas.

Methods expert interviews and internet discussion

The interviews focused on four global themes:
- Climate change
- Food
- Health
- Waste

Per theme, four experts were interviewed in order to identify what exactly the global change problems amount to, what the most important solutions are and if biotechnology could be a solution in their view. Each interview lasted 20 to 30 minutes and was conducted by telephone. We have sent the interview questions to the experts in advance. Almost all experts approved their interview report. Only Michel Dutang was not able to respond to our e-mails and telephone calls.

In order to involve stakeholders in this discussion and give them the opportunity to give their opinion and discuss the societal threats and opportunities, Schuttelaar & Partners set up a discussion website:

www.globalchange-discussion.org. The four themes in this project, climate change, food, health and waste, were at the centre of the website. Five times, more than 250 stakeholders received an e-mail with an invitation to participate in the discussion. Because there wasn´t much response to the internet discussion, the results of this discussion are not mentioned in the executive summary.

Results expert interviews

Biotechnology is certainly not the 'silver bullet' solution to global changes, but it can contribute, in one field more than in the other. That is the general conclusion from the 16 expert interviews on global change and biotechnology. Most experts believe that socio-economic and political changes are needed to solve the problems involved in global changes. The experts focus on a systems approach, systems innovation, political will, a new approach (of waste) and a new appreciation for farmers.

If we look at biotechnology in the field of food, specific biotechnological techniques, such as marker assisted breeding, gene silencing and transformation, can be used to increase food productivity. The consequences of climate change might be intercepted by developing crops that can grow in dry, saline or wet conditions, either by using conventional or biotechnological techniques. In the field of waste, biotechnology could be used for some categories of waste. For the valorization of solid waste it is probably too expensive, but for bio remediation of land, waste water purification and biofuel production from organic matter biotechnological techniques are already extensively used. For global changes in the field of health biotechnology can play a role on both the diagnostic as well as the treatment side (for example by pharma crops and neutraceuticals), although it seems very expensive on the treatment side.

When we consider biotechnology as a solution, we first must do a needs assessment. Do we actually need this technique, what will the consequences be if we use it, what will be the consequences if we don´t use the technique? In all cases,

- GMOs should not negatively affect human health or the natural environment;
- the public should accept the use of GMOs to solve the problem;
- the consumers' freedom to choose should be respected at all times.

These results are in line with two other projects Schuttelaar & Partners conducted for COGEM: the interviews with international experts for the Trendanalysis Biotechnology 2004 and the project on biotechnology and religion (2006).

Results case studies

The question how technology can help to solve societal problems can be formulated in terms of agendas: how can technological and societal agendas be harmonized? The Wageningen UR part of the project addressed the problem of gaps between those agendas, searching for leads that could help to bridge them. We took our theoretical point of departure in the relatively new field of Science and Technology Studies that focuses on "the sociology of expectations", as it gives a clear diagnosis of how technological agendas get "out of hand". For empirical substance we chose two case studies, one on biofuels and one on saline agriculture.
The sociology of expectation focuses on the performative role of future expectations in shaping initiatives and innovations. Forecasts and scenarios play important roles here.
Most forecasts are framed in a technological deterministic fashion, neglecting the co-evolution of technology and society. They also assume that new technologies will substitute for old technologies, neglecting the fact that innovations will have generation effects besides substitutions effects. The most troubling feature of forecasts arises from the 'dynamics of hype'; promises about the future potential of new technologies are vital in attracting attention and allies, but hype and high hopes will inevitably lead to dissatisfaction and disillusionment. Especially in combination with deterministic and simplistic views of technology development, this 'hype dilemma' will have a deteriorating effect on moral and social deliberations. It can lead to 'speculative ethics' that turns a blind eye to the social problems at hand, and it can also lead to extreme black-and-white thinking and a counterproductive polarisation of the debate. The methods of 'visioning' and 'roadmapping', that currently came into fashion for imaging the future, suffer from the dynamics of hype and promote a tunnel vision, which leaves scarce room for critical discussion and alternative options.
Against this theoretical background, we addressed the two case studies. In the biofuels case, we zoomed in on details of the creation of tunnel vision, while in the case of saline agriculture, we took a wider view, comparing the fates of different innovative frames, including a low tech one, to problems of agriculture and salinity.

As to **biofuels**, the initial hope was that by looking more closely at the frames and scenarios, visions and roadmaps in which those agendas were formulated it would also be possible to discern promising technological routes and options for promoting climate change mitigation and adaptation, sustainable development, and the reduction of world poverty and hunger, in other words, possibilities for furthering the societal agenda of the Millennium Goals. Alas, this hope was soon dissipated when it was found out that 'visioning' and 'roadmapping' exercises had not really been set up to explore a wide range of possible futures. Instead, they had quickly zoomed in on the setting of specific targets for specified future dates that were attractive to a limited set of stakeholders, without much regard for the global effects of adopting such targets. As a consequence, as Oxfam International wrote in a recent report entitled *Another Inconvenient Truth*, the promise of a "sustainable development opportunity" has been quickly turned into "an unsustainable nightmare": it appears that current European and American biofuel policies are actually deepening world poverty and accelerating climate change. European Commissioner for Development Louis Michel also recognizes that the fashion for biofuels could be a catastrophe. In the light of these developments, the Wageningen UR team holds that the central question is not so much what biotechnology, or any other technology, can contribute to solving global problems, but should rather be what makes innovation agendas sensitive to hypes, and what would be required to make them more hype resistant.

The case study on **saline agriculture** distinguishes three different ways to frame issues of salinity. The first asks for a change of perspective on saline soils in the Netherlands: to see them as a challenge for innovation rather than (just) as a problem. It does not primarily count on new technology, but mainly on more positive ways to frame salinity, stressing that many traditional plants are already available for saline agriculture. The other two framings are associated with new technology. The "algae for biofuels" frame is a moving target that changes with new technological frontiers, and the associated societal problems for which it promises to offer solutions change accordingly, in opportunistic and unpredictable ways. The frame seems subject to random drift. In the "climate-ready" frame, genetics, and in particular GM-methods, are presented as a solution to the problems of climate change, including increasingly saline soils. This frame puts GM central. The accompanying debate makes it clear that the focus of GM debates is shifting: issues of power and intellectual property are becoming more central than the technology itself.
The low technology frame is not doing well on the innovation agenda. The case study notices that the association between innovation and new

technology has created a climate in which low tech innovation is almost a contradiction in terms. Like the biofuel case, this study confirms that a fixation on new technology makes the innovation agenda derivative of technological frontiers and creates a succession of hypes. As a consequence, pressing societal problems easily disappear altogether from innovative sight in unpredictable ways.
In order to counteract this hyping and drifting, a more robust societal innovation agenda is needed.
Given this need for societally defined innovation agendas, the turn of GM debates towards issues of power and intellectual property is promising. At first sight, polarization continues in familiar ways, but reality turns out to be far more complex, undermining the view that GM seeds are bad for poor farmers. If GM debates respond to these new complexities of social reality, they can certainly represent a step towards a more robust societal innovation agenda. Rather than being derived from the frontiers of technology, a robust innovation agenda primarily builds on (sufficiently complex) analysis of societal issues. Within such an agenda, innovation is not associated with new technology per se.

Taking these results together, it can be concluded that they are in large part in line with findings within the sociology of expectations. In particular, they confirm the large role of technological hypes, and the need to "become more sensitive to the many hidden futures that hype so often silences", in the phrasing of Nik Brown. In looking for ways to boost this sensitivity to hidden futures, the case studies show leads on several levels. The biofuel case, focusing on the creation of tunnel vision, predominantly points out the importance of more room for technological scepticism. The saline agriculture case relativizes the close identification of innovation and new technology, pointing to the importance of room for low tech innovation frames. The two levels need each other: technological scepticism cannot develop any long term vision without a wider framing of the problems, while those wider framings cannot develop practical force without the details of technological possibilities and impossibilities.
The Wageningen part of the study thus points to the benefits of a more "conservative" innovation agenda, in which scepticism to the latest technology is cherished, as well as a wide and pluralistic search of alternative societal framings. Summarizing very briefly, our study identifies the following hype-promoting mechanisms and their potential solutions.
Hype-promoting elements are:

- a preference for unity and consensus
- technological optimism and enthusiasm
- fear to "miss the boat"

- technology driven agenda setting (with loss of prior societal problem definition)
- narrow framing, with neglect of complexities
- a marginalization of local and low tech innovation

In the search for more hype-resistant innovation agendas, each of these items is a potential point of departure. Thus, elements in the search for hype-resistant agenda setting are:

- active effort to organize dissensus to decrease the temptations of consensus.
- a cultivation of technological scepticism
- active guarding of the quality of the innovation agendas from a social perspective
- do sufficient justice to complex causality in the framing of problems
- loosening of the connection between innovation and new / immature technology

Common conclusions

Biofuels and food prices put biotechnology high on the agenda again as a source of potential solutions. This is reason for caution, not primarily concerning biotechnology, but concerning the narrow way these agendas tend to be formed and developed.

The experts that were interviewed mentioned many specific potential contributions of biotechnology to global problems, although progress is not always fast. While fifteen years ago, it sometimes seemed as if biotechnology could solve all the world's problems, many solutions are still on the lab table and not implemented in practice. But perhaps more importantly, the conditions under which biotechnology can have beneficial effects emerge as a central issue, from both sides of the project. In the interviews, it was repeated again and again that biotechnology is not a magic bullet but should be seen as (just) one of the tools that can have a place within a wider (political, social) framing of the problem situations. It was widely felt that biotechnology does not deserve a higher place on the agenda than it now has, perhaps on the contrary. The latter view is in line with one of the conclusions from the Wageningen part of the study: that the less attention biotechnology receives as a technology, and the more it is included within a robust societal agenda, the more constructive its role can be.

This conclusion also is a reason for some reflection on the original question as it is posed by the COGEM, or perhaps on the whole approach embodied by the COGEM, in which one particular technology is the starting point of deliberation. The question what this technology can or cannot contribute to problems keeps our attention almost unavoidably focussed on this technology, even when in the wider context of the societal problems to be addressed, the role of this technology may be present but secondary. A continued emphasis on this role then amounts to an overemphasis on the technology, and the perspective on societal problems becomes a technologically skewed one.

The common perspective from both sides of the study is that the use of biotechnology needs to be embedded in wider problem analyses which include social and political aspects. Such wider analyses redirect the locus of debate and may take away some of the high expectations, high hopes and high fears from biotechnology. The potentials of biotechnology may then be judged in a spirit that is more accepting and more skeptical at the same time.

Global change, what solutions does biotechnology offer? - Schuttelaar & Partners

Ank Jansen and Fridus Valkema

1. Introduction

Global changes are widely believed to be caused by a growing world population and increasing economic and industrial activities. Some obvious examples include the increase of CO_2 in the atmosphere, pollution, deforestation, possible shortages of (drinking) water and hunger.

With this project, the Netherlands Commission on Genetic Modification (COGEM) is investigating the ways in which biotechnology, especially genetic modification, may contribute positively to global change. Schuttelaar & Partners has interviewed 16 experts in the fields of climate change, food, health and waste and set up an internet based discussion to involve stakeholders.

2. Conclusions

Biotechnology is certainly not the 'silver bullet' solution to global changes, but it can contribute, in one field more than in the other. That is the general conclusion from the 16 expert interviews on global change and biotechnology. Most experts believe that socio-economic and political changes are needed to solve the problems involved in global changes. The experts focus on a systems approach, systems innovation, political will, a new approach (of waste) and a new appreciation for farmers.

If we look at biotechnology in the field of food, specific biotechnological techniques, such as marker assisted breeding and gene silencing, can be used to increase food productivity. The consequences of climate change might be intercepted by developing crops that can grow in dry, saline or wet conditions, either by using conventional or biotechnological techniques.

In the field of waste, biotechnology could be used for some categories of waste. For the valorization of solid waste it is probably too expensive, but for bio remediation of land, waste water purification and biofuel production from organic matter biotechnological techniques are already extensively used.

For global changes in the field of health biotechnology can play a role on both the diagnostic as well as the treatment side (for example by pharma crops and neutraceuticals), although it seems very expensive on the treatment side.

All experts mentioned preconditions for the use of biotechnology:

- GMOs should not negatively affect human health or the natural environment;
- the public should accept the use of GMOs to solve the problem;
- the consumers' freedom to choose should be respected at all times.

Most of the experts say that biotechnology already is high on the agenda, so does not need more attention, or even needs less attention.

What sticks out is that the food and climate change experts strongly focus on current events in these fields, that is the food versus fuel discussion.

The interviews for the themes waste and health more describe the events that occur on the background and that aren´t in the news so much.

Furthermore, this is more an impression then a conclusion, there are two topics we expected the experts to mention, but they did not: the Cradle to Cradle philosophy and the domination of the multinational agricultural biotechnology companies.

3. Methodology

Expert interviews

We have selected 16 internationally recognized experts in the fields of climate change, food, health and waste. We have interviewed two types of experts: experts from the problem side and experts from the solution side. In practice, many of the experts had knowledge of problems and solutions in their field of expertise, so we ignored this difference during the analysis of the interviews.

As much as possible we differentiated in known position towards biotechnology, sex, geographical origin, generalist vs. specialist and background (science, industry, etc.). We have invited 31 experts to participate. The following 16 experts were actually interviewed:

- Joachim von Braun, Director General of the International Food Policy Research Institute in Washington DC in the USA
- Cees Buisman, Professor in biologically sustainable technology and scientific director of Wetsus in the Netherlands
- Yves Champey, Advisor to the Director General of Evry Genopole in France
- Michel Dutang, Head of research at Veolia Environnement in France
- Hans Eenhoorn, Associate professor Food Security and Entrepreneurship at Wageningen University and Research Centre and member of the UN Taskforce on Hunger in the Netherlands
- Fabio Fava, Professor of ”Industrial & Environmental Biotechnology” at the University of Bologna in Italy
- Ian Gust, Professorial Fellow in the Department of Microbiology and Immunology at the University of Melbourne in Australia
- Niels Jørn Hahn, President of the International Solid Waste Association in Norway
- Hans R. Herren, President of the Millennium Institute in Washington
- Birte Holst Jørgensen, Managing Director of Nordic Energy Research in Denmark
- Richard Laing, Medical officer at the World Health Organisation and author of the Priority Medicines for Europe and the World report in the United Kingdom
- Susan Leschine, Professor in microbiology at the University of Massachusetts in the USA

Discussion on the climate page

- Martin Parry, Chair of the Intergovernmental Panel on Climate Change's Task Group on Scenarios for Climate Impact Assessment in the United Kingdom
- Monkombu Sambasivan Swaminathan, UNESCO Chairman in Ecotechnology at the M.S. Swaminathan Research Foundation in Chennai, India and Chairman of the National Commission on Agriculture, Food and Nutrition Security of India
- Marcel Tanner, Director of the Swiss Tropical Institute in Basel in Switzerland
- Coleen Vogel, Professor of Sustainability at the University of the Witwatersrand and member of the Scientific Committee for Global Change in South Africa

Each interview lasted 20 to 30 minutes and was conducted by telephone. We have sent the interview questions to the experts in advance. Almost all experts approved their interview report. Only Michel Dutang was not able to respond to our e-mails and telephone calls. You can find the full interview reports in appendix 1.

Internet based discussion

In order to involve stakeholders in this discussion and give them the opportunity to give their opinion and discuss the societal threats and opportunities, Schuttelaar & Partners set up a discussion website: www.globalchange-discussion.org. The four themes in this project, climate change, food, health and waste, were at the centre of the website. Within each theme participants can read the synopsis of four interviews, the full interviews and they can give your comments. So actually there were four discussions on the website.

Homepage of www.globalchange-discussion.org

On April 9 2008, we have sent an invitation to participate to more than 250 stakeholders from 24 countries in Europe, of which almost one third originated from the Netherlands.

We have sent four reminder e-mails: on May 2nd, 8th, 15th and 21st. Each reminder e-mail contained one statement of an expert per theme. In each e-mail there were different statements, so all 16 experts had a statement in these e-mails.

Furthermore, we have sent out a request to several newsletters to ask them to put an announcement of this discussion website in the newsletter. This worked out for five newsletters: AgBioWorld, CheckBiotech, CropBiotech, Genetic News and the newsletter from the Netherlands' Biotech Industry Association, NIABA.

The discussion was closed on May 28th.

The statistics for the website can be found in appendix 2.

4. Analysis of the interviews

In this chapter we summarise the main problems and solutions given by the experts. Separately, we summarise their views on the use of biotechnology as a solution and under which conditions biotechnology can be used.

Food

The main problem mentioned by the experts is the competition between food, fuel and feed, resulting in less available land for food crops. Feed crops are used for feeding cattle to produce more meat. Fuel crops are used to develop biofuels. This causes an immense rise of the food prices. According to the experts we simply must not use suitable farm land for fuel crop production. Hans Eenhoorn says: "One SUV tank with bioethanol made of corn can provide food for one person for a whole year." Furthermore, we must add value at farm level to increase farmers' income. One way to do this is to carry out large programs to make small-scale agriculture more productive and to realize a higher yield. We need a lot of investments to reach this. Lastly, we need governmental support to reach these goals. Western countries have to put pressure on African governments to take action.

The second problem is the increasing world population and globalization of the food system. Joachim von Braun: "There is a food system in operation now that requires a global response to supply issues. This global system is integrated in information, trade and technology." Because the world population is rising and more and more land is being used for fuel crops, we need an increased food productivity, but only in a sustainable manner. Buffering possibilities are very low at the moment. To solve this, we need better water and soil management, a new technological revolution – biotechnology could be part of it - and integrative production systems that maintain ecological diversity. M.S. Swaminathan: "We need food for all and forever, in an environmentally friendly and socially sustainable basis: the evergreen revolution. 'Evergreen' is defined as productivity in prosperity without ecological or social harm." We therefore have to integrate animals with crops in farming systems to increase soil fertility and reduce excess manure, energy use and abuse of antibiotics and hormones. Also public food and nutrition programs that support the poor might be a solution. Finally, farmers should be paid for ecosystem services. Hans Herren: "This means we also have to take care of other goods that agriculture produces not only

the food, feed, fibre and fuel. I also support the idea that farmers be paid for the ecosystem services, only so can we make sure that they will be taken care of."

Third important problem mentioned by the experts is climate change. We have to start developing new crops that can cope with for example drought, water or saline stress. Developing the ability to forecast climate variations can help farmers to anticipate using different varieties of crops. We can use biotechnology for this purpose and also for facilitation of a higher return on biomass for the production of biofuels. "But", M.S. Swaminathan says, "we should also invest more in renewable energies like solar, wind, wave motion and thermal energy. For energy security we should develop an energy mix, involving all these types of energy." Furthermore, we must make farming systems resilient against extreme weather conditions. A social network and insurances are needed to back farmers for climate risks.

Biotechnology treats symptoms, not the cause of problems. It is therefore not the preferred solution. But specific biotechnologies, such as assisted breeding, gene silencing and transformation, can be used to increase food productivity and develop crops that are resistant to drought or rain or can grow on acid and salty soils. If we use genetic modification, a detailed needs assessment is necessary. We do not understand enough the ecological, health and societal implications of GM crops. The consumers' freedom to choose must be respected at all times. Joachim von Braun: "GM crops are controversial and this won´t go away fast. It´s all about personal choices and people should be given these choices."

Climate change

The biggest problem in the field of climate change is the high energy consumption due to transportation, domestic use and industrial use. Birte Holst Jørgensen: "Energy consumption is an integral part of our economic activities. So with improved world economic development we also experience increased energy consumption. These developments have a major impact on the climate." This leads to high greenhouse gas emissions (such as CO_2). Consequence is global warming. To limit this, we must develop more efficient and cleaner conventional techniques, such as carbon capture and storage) and we must develop further renewable energy techniques, such as solar, wind and bio-energy. Especially the biofuels are promising, and we should speed up developments of the second and third generation of biofuels. Under no condition we should stimulate the use of

food crops for the production of biofuels. Susan Leschine: "At present, plant biomass is the only significant source of liquid transportation fuel that may replace the world´s finite supply of oil." In order to find solutions, we must have a dedicated R&D effort to explore all opportunities. To establish changes in domestic use, major life style changes are necessary.

Second problem is to make international agreements as a follow-up for the Kyoto protocol and to make implementation plans for adaptation on a local scale. In order to do this, we need international agreement on the problem, on the solutions and on the timing of the solutions. Because climate change can differ on a local scale and because all countries have different interests, this is very hard.

Third problem is the lack of knowledge of global climate change systems. We don´t know what will happen on a global scale, let alone on a local scale. To develop these systems, we must involve all stakeholders to see what they need in a climate model. We must avoid seeing climate change only from a scientific point of view. Coleen Vogel: "This is necessary because we should also research more on how people are responding to climate change and future adaptations that may be required." What we need is political will and the capacity to do this.

Biotechnology can, under specific conditions, definitely play a role to reduce climate changes. The use of biotechnology should not pollute the environment or threat biodiversity. This means it should be used in a controlled way. Furthermore, the public must accept the use of biotechnology. We therefore should not rush into things and thereby create new problems. Martin Parry: "Biotechnological solutions are important because some farming systems, which have developed in tune with current climate, cannot easily be modified to adapt to climate change without the help of biotechnology. In some parts of the world we must expect new climates that don´t exist anywhere else and for which crop plants have not naturally developed, because their environment hasn't existed."

Waste

In the field of waste, there are a lot of new opportunities because the valorisation of waste, that is: to retract high value materials and energy, can help to reduce climate change. Especially organic matter, paper and plastics are suitable for valorisation. Furthermore, waste is also fit to retract bioactive molecules for food, chemical, pharmaceutical, cosmetic, textile and energy industry. Favio Fava: "Organic waste is often classified

as waste to dispose of and its disposal generally relies on costly and destructive procedures. However, several of such waste streams are sources of interesting bioactive molecules."

One problem is that the valorisation process must be industrialised. At the moment, most of the handling in the waste sector is done by people. The valorisation is therefore still a costly business. Intensifying research by companies, supported by governments, for example by fiscal incentives, can support valorisation. Research should focus on energy recovery of materials and on the homogeneity of material, because that is crucial to get the desired efficiency and reproducibility in the process.

The second problem in the field of waste is the lack of treatment facilities. Waste industries do not have enough capacity to process all the waste. Most waste is therefore land filled, which can cause health and environmental problems, especially in developing countries. Existing plants need to be automated and the plants need facilities to screen materials for toxins, for example X-ray detection for toxins detection in organic waste. In the debate about treatment facilities, we must involve all stakeholders and base the discussion on facts, not on feelings. Furthermore, we need political will to resolve this problem.

In the field of waste water, the influence of active biological compounds on nature is a problem. These compounds can be oxygen demanding, nutrients (e.g. phosphate or nitrogen) or poisonous compounds (e.g. copper or sink). The water might lose all oxygen, so everything in the water dies. Another possibility is that the water will become green soup because of the growth of algae. The active biological compounds accumulate and because they are so small, they are hard to remove. The question is whether we have to remove the compounds one at a time, or do we need a new concept of water purification? Cees Buisman: "It is not feasible to provide the rest of the world population with the same drinking water that we are used to in the Netherlands. A process technology approach is more feasible."

"But", Niels Jørn Hahn says, "the debate we have now on global warming and global change is a gift to the waste management sector. Waste is an opportunity for energy production and for the reduction of CO_2 emissions."

Biotechnology can be part of the solution for some categories of waste. For the valorisation of solid waste it is probably too expensive and only suitable for high value products. Michel Dutang: "For example CO_2, the solution will

be a physical solution with underground storage. Biotechnology will probably be too expensive to develop a solution for this problem."

However, biotechnology can be a solution for bio remediation of land and biofuel production. For waste water purification biotechnology is only suitable for compounds that can be used by bacteria, such as oxygen demanding compounds, nitrogen and sometimes phosphate. It is not necessary to develop GM bacteria for this application, because there are plenty bacteria that can do the job, you only have to find them. Furthermore, it is impossible to keep these bacteria in a closed environment, because there is so much waste water.

Health

The most important problem in the field of health is the poor health systems all over the world, resulting in inequality for people and not enough access to health tools and research results. Most health systems are not well developed or located in the periphery. Furthermore the collaboration between different service providers is not sufficient. It is not just a matter of money, the focus is not right. We should therefore focus on a more systemic approach and develop the economic situation of poor countries. Economic development usually resolves poverty related diseases. We have to be able to diagnose common disease quickly and provide basic treatment. Ian Gust: "We have to implement effective approaches and make optimal use of products that we already have, but which we have not utilised to their greatest effect."

We also need more human resources. Marcel Tanner: "If you really look at for instance the Millennium Development Goals; if you calculate what you need in terms of people working in the health sector to reach these goals, you will find that most countries have substantial deficiencies in human resources to be able to reach these noble goals."

Another important problem is the lack of awareness of chronic diseases, such as cardio vascular diseases, diabetes and respiratory related diseases, in most developing countries. We don´t realise that this is becoming a very big problem. Medicines are available, but may be further developed into a poly pill: a combination of different medicines. Organisations such as the World Band and the Clinton Foundation only in few diseases with a high political profile, such as HIV, TB and malaria. But in a lot of developing countries, such as India, there are 10 to 100 times more patients with chronic diseases.

Third problem is the decline in innovation at big pharmaceutical companies because of high investment risks and regulatory barriers. A solution is to reduce regulatory requirements for phase II and III and set up a public fund for phase IV, the monitoring. We would have to label new medicines with 'not yet proven safe' for the first 3 to 5 years.

Climate change can also be seen as a problem in the field of health. Climate change will have an effect on nutrition; people will then be more susceptible to diseases. It will also have an effect on rainfall; insect borne diseases will become more common where rainfall increases. To solve this we need behavioural changes, but problems will probably first have to get worse and resources (such as water) nee to be given a realistic price.

Biotechnology is an enabling rather than a transforming technology in the field of health. It can play a role on the diagnostic side, for example for the distinction of different types of a disease, and possibly also on the treatment side, for example by pharma crops and neutraceuticals. Richard Laing: "I am very sceptical of biotechnology, because of the costs of manufacturing biotech therapeutic products. I think for diagnostic biotech products are far more likely to be successful by using biotech products to identify genes or metabolic defects. I think that is an area where they have real promise." Yves Champey: "Biotechnology can play a role on the treatment side, not on the prevention side. But it will probably be restricted to rich communities, because it will be a costly treatment."

5. Summary of the internet discussion

In this chapter we summarise the opinions of the participants of the discussion.

Introduction

21 persons registered to participate in the discussion. 7 participants came from the Netherlands, 5 from other European countries, 1 from USA, 3 from Africa and 5 from Asia. 6 of the 21 participants were directly invited, the other 15 received the invitation by some other way.

Food

- We should shift the focus of the debate from the present commercially available applications, which are contested for good reasons, to future needs and the question which types of solutions are available or should be developed.
- GM is not the one, but certainly one of the options that should be assessed on a triple-P basis. One option is cisgenesis.
- The problem is not the low food cost. Low food costs and increasing production costs would have led to reduced production and shortages anyway. What we need is biofuels or any other alternative outlet for agricultural products that will allow growers to make some profits.
- Increasing food costs has multiple reasons. Biofuels is just one, organic farming (lower yield per hectare and higher price) is another. Organic farming is a luxury industrialized countries can still afford, but should rethink their strategy.
- We should increase productivity, and we can only do this if we adopt a holistic and complete package of practices for crop growth.
- Please be aware that it is not a magic wand or magic bullet.
- Biotech will be needed to increase productivity, to maintain soil fertility and possibly to improve existing crops to withstand stressors such as drought.
- Local food production uses our natural resources inefficiently and not ecologically nor economically sustainable. Furthermore, we cannot depend on local production only as some global regions cannot be self-sufficient, while others have a surplus production potential.
- Please remember that the small farmers form 70% of the agrarian population and he/she has a big role in sustaining the food security of the world.

- We are aware of the possibilities of biotechnology, but at what cost and who meets the costs? Governments need policies that demonstrate that this will not be just an avenue for corporate interests and exploit the poor and vulnerable who desperately need food, but a long term sustainable and affordable solution to food security and poverty.
- The world food problem is not a matter of quantity, it is a matter of unequal distribution of food between poor and rich people.
- A study from 2005 from the European Commission Directorate General summarises strategic actions for EU support the development of pro-poor (red, green, white and blue) biotechnologies in the South. This study must be included in this discussion and can be found at http://www.sbcbiotech.nl/page/downloads/Final_Report_-_Guidelines_Biotech_DCs_2005_Annexes.pdf.

Climate change

- I believe that climate change is a global challenge for which we have to work together, including the application of modern biotechnology.
- We must not forget the role of ozone (O_3) in climate change. It s a secondary pollutant that will have a major role in crop yield. We should start monitoring its effects.
- Drought, thermo and salinity tolerance, resistance to diseases and pests and enhancing water, nitrogen and potassium use efficiency are traits that need to be engineered into plants for climate change adaptations by plants.
- We must not hasten with the applications of biotechnology, we most proceed on a precautionary note.
- I am in favour of applying GMOs, but using climate change, food shortage and development issues as a means of softening the public will not help the case if there are no real examples and no concrete improvements are made.
- There is no such thing as an immediate (global) solution and any risk analyses should be taken seriously.
- I agree with Professor Vogel that different types of people should be consulted when implementing biotechnological solutions. In Ghana we can show a success story of this approach.

Waste

- Biotechnology has to be employed to organise composting in a manner that is less emission extensive and also design crops and cropping systems that can adapt to organic inputs.

- It is time now to use biotech tools that look at more efficient forms of nutrient utilisation.
- Our present perceived fear for all kind of micropollutants is increasing. Many of these compounds have been there already for a long term, the effects are very difficult (or not) to prove at the concentration levels in nature. Yet we are wanting to add all kinds of resources and energy demanding processes to combat this perceived fear. The society should better focus on what risks it wants to accept or how individual risk evaluations can be better incorporated in society.

Health

- Getting sick has always been a part of life. It is not to be controlled by pills (that really doesn't work in the long run, those bacteria and viruses will outsmart us), but by less pollution, less chemicals, less warfare and other stress factors.

The announcement of this discussion website apparently did not disperse into the health sector, resulting in a poor health discussion. Furthermore, health in general seems to give less discussion in the biotechnology sector.

Global Change, Global Ethics and Biotechnology – Wageningen UR

Henk van den Belt, Cor van der Weele & Jozef Keulartz

The first section is a general introduction; the second and third section present case studies, which are different in character. The biofuels case zooms *in* on the present technological search for biofuels, unravelling its methodologies, rhetorics and one-sided enthusiasms in some detail. It thus reconstructs how tunnel vision is created. The case on saline agriculture zooms *out* of the technology, looking at different ways to frame the problem of salinity and noting that some societal problems may suffer from neglect when innovation agendas are strongly associated with, and derived from, new technological frontiers.

Different as the case studies are, they agree in their concluding expectation that hype resistance will be boosted if innovation agendas become more consistently geared to present day societal needs and problems, and become a little more independent of high tech initiatives, promises and controversies.

1. Introduction: The dynamics of future expectations

Politicians and policy-makers inevitably make use of and rely on forecasts and future scenarios with respect to technological developments, but the predictive value of most of these expectations turns out to be disappointing. This asks for an explanation because future visions and expectations seem to have the dynamics of self-fulfilling prophesies: they are important to attract attention and allies, to stimulate agenda-setting processes, to foster investment, to mobilize resources, and to give direction to research and development activities. Given this performative role of expectations in shaping initiatives and innovations it seems curious that their predictive value often is so insignificant. Three (closely related) key features that may cause forecasts to fail are mentioned in recent literature on the sociology of expectations, a subfield within Science and Technology Studies (STS) (Keulartz & Schermer, fortcoming).

1. Technological determinism

First, disappointment seems to be built into the way most forecasts are framed in a technologically deterministic fashion, downplaying the social and cultural contexts of technological developments and over-emphasizing the autonomous development of technology. "The number of successive disappointments in fields as diverse as biotechnology, e-commerce, stem cells and nanotechnology have resulted in lasting damage to the credibility of industry, professional groups and investment-markets. That is, until the next promise arrives!" (Borup et all., 2006: 290) To prevent such disillusionment we need to develop "a more sophisticated appreciation of the co-evolution of the social and the technical" (Brown & Michael, 2003: 8).

2. The idea that new technologies substitute for old technologies

A second problem with most forecasts and future visions is the suggestion that new technologies will substitute for existing one. A good example is the notion of a complete transition from a fossil-based economy to a bio-based economy (section 2). Nik Brown mentions the example of gene therapy that was once thought to entirely dispense with the need for pharmaceutical medicines and compounds. "The medicinal approach to managing symptoms would be replaced by a therapeutic framework based

on the idea of genes as the cause of diseases from within and genes as a means of countering our vulnerability to disease from without" (Brown, 2003: 11).

Another example is from Frank Geels and Wim Smit's paper on the future expectations of the impact of ICT on traffic and transportation. They point to such phenomena as tele-conferencing, tele-working and tele-shopping that were supposed to lead to a replacement of paper products (the so-called paperless society') and to a reduction of or substitution for business travel, commuter traffic, and physical shopping.

The idea that new technologies substitute for old technologies is misleading, because in reality old and new technologies often co-exist and service different markets and customer groups. "The electronic information storage and transmission technology did not result in the expected "paperless society". By contrast, even more printed paper is being produced: not a "paperless society", but a "printing office" emerged. In addition to a (small) *substitution* effect, a *generation* effect is taking place" (Geels & Smit, 2000: 877). The same is true with respect to the impact of tele-working on commuter traffic. The reduction in commuter traffic may have gone hand in hand with an increase in recreational or social traffic. "Tele-working, therefore, may well have traffic *generation* effects besides *substitution* effects" (ibid., 876).

Both technological determinism and the idea that new technologies replace old ones provide us with overly simplistic images. According to Rein de Wilde this is an important constant factor in our thinking about the future:

> "One constructs a rather linear or one-dimensional image of this future. One makes it appear as if the future is the result of a coherent social process that has only one single direction, goal or mechanism. We encountered this type of linear 'progression thinking' among modernists… Present-day future-guru's, however postmodern, however, stay stuck in the same framework. … The presuppositions which Isaiah Berlin believed to be characteristic for the utopian tradition appear to be at work here as well: there is one single road or solution, there is one single method, while the existence of fundamental dilemmas is being denied and conflicts are being played down" (De Wilde, 2000: 198-9).

The belief in a single trajectory of technological progress is underwritten by folk historiography such as simple extrapolations of 'Moore's Law' (Alfred Nordmann, 2007b: 231). An example is the entrepreneurial researcher J. Craig Venter, who invokes a generalized version of Moore' law,

which claims that science and technology will grow exponentially, to silence the criticism of biofuel sceptics (section 2).

3. The Hype Dilemma

Another troubling feature of future scenarios of new and emerging technologies arises from what Nik Brown has called the 'hype dilemma' (Brown, 2003). Because the performance of new technologies is initially low, while costs are high and uncertainties are manifold, promises about the future potential of new technologies are crucial to attract attention and allies, to foster investment and mobilize resources. Next, however, hype and high expectations will inevitably lead to disappointment and disillusionment – reputations will be damaged, not only of individuals but of entire innovative fields, and public trust and support will be lost.

The biofuels case (section 2) is a perfect example of the dynamics of hypes. In a relatively short interval, public appreciation of biofuels changed dramatically from being a panacea for the world's environmental and energy problems to the primary scapegoat for global injustice and glaring failures in conservation and environmental protection.

Section 3 on saline agriculture also presents examples of quick cycles of attention. For example, the idea to boost the sea as a source for carbon dioxide binding by fertilizing it with iron to stimulate phytoplankton growth (including algae) has come up, blossomed for a few months and (for the time being) gone under again, because of the uncertain ecological impact. To the extent that social agendas are dependent on technology development, they are thus sensitive to the vicissitudes of the new technology, and may be drifting with these vicissitudes more or less randomly, from a social point of view.

The hype dilemma, especially if combined with deterministic and simplistic vies of technology development, can have a corrupting impact on ethical deliberations. It can lead to what Alfred Nordmann has framed as 'speculative ethics' and it can lead to extreme black-and-white reasoning.

4. Speculative ethics

Because ethical concern is a scarce resource and must not be squandered on incredible futures, Alfred Nordmann (2007a) cautions us to refrain from what he calls 'speculative ethics'. Speculative ethics discusses the pros and cons of emerging technologies *as if such technologies were upon us*

already. Speculative ethics suffers from an 'if-and-then syndrome' in which possibly emerging technologies are presented as actual ethical issues. He gives the following examples of this syndrome:

> "If it should be possible to create a direct interface between brains and machines, this research threatens an invasion of privacy when machines are used to read human minds. If molecular manufacturing were to be achievable within the next 20 to 50 years, we need to prepare for an age of global abundance and thus a new organization of our economies. If the development of machine intelligence leads to ever greater machine agency, we need to adjust our criminal codes to hold machines responsible. Also, if nanomedical lab-on-a-chip diagnostics and genetic screening technology become standard practice, there arises in many more cases the predicament of knowing a condition or disease where there is no treatment or cure. And if, finally, it is scientifically possible to extend human life-expectancy indefinitely, any objections to this research agenda are tantamount to murder or at least to the failure of coming to the aid of a dying person who can be saved" (Nordman, 2007a: 33).

John Dewey has criticized this kind of speculative ethics because if we are ecstatically focused on a future end this will lead to the impoverishment of our present imagination. When our imagination is contracted, we do not attend to the world's possibilities. Or, as Steven Fesmire has once put it: 'Human imagination is drained when the process fades while products become focal. Pursuing our ends with the imaginative amplitude of moths thronging to a flame nurtures in us the cognitive prowess of moths' (Fesmire, 1995: 53).

First, subordinating the present process to the future product indefinitely postpones the goods for which we currently struggle, thereby impoverishing the intrinsic significance of the present. Second, such subordination limits our capacity to forecast possible courses for attaining good in the future. "Is there any intelligent way of modifying the future except to attend to the full possibilities of the present?" Dewey asks rhetorically.

5. Black-and-white thinking

The other problematic impact of hype is that it "tends to produce an artificial polarised form of ethical discourse at odds with the practical realities of the science" (Brown, 2003: 7). To attract attention, allies and large-scale investment potential benefits are hyped up and risks and costs are played down. But this will generally provoke a reaction and fuel and enflame widespread concerns and anxieties about risk. "Risk and

opportunity are the flip sides of hyperbolic expectations, inflating one another in equal measure" (ibid., 4).

As a result of the polarising effects of hype public debates on emerging biotechnologies often oscillate between two extreme positions: a utopian and a dystopian. Literary fiction and visual arts fuel these scenarios: books like Brave New World or 1984, or films like Gattaca and the Boys from Brazil.

A very striking example of how these two scenarios set the scene for the debate is provided by the debate on human enhancement through new biotechnologies. This debate is polarized between two extremes. On the one hand there is the transhumanist movement, consisting of a number of scientists, philosophers and publicists, which aims to enhance the human condition by way of technology. The World Transhumanist Association advocates the ethical use of technology to expand human capacities. As their website states: "We support the development of and access to new technologies that enable everyone to enjoy better minds, better bodies and better lives. In other words, we want people to be better than well."(WTA website)

On the other hand there are scientists and philosophers, called bioconservatives or neo-Luddites by their transhumanist opponents, who caution and argue against the expansion of biotechnology in general and enhancing technologies in particular. An otherwise diverse set of authors, such as Leon Kass, Francis Fukuyama, Michael Sandel and Jeremy Rifkin, all argue that the use of biotechnology to enhance human traits bears great risks with regard to our safety, our dignity or even our humanity. While the transhumanists paint a utopian picture of the future, where everyone is happier, healthier and lives longer, the bioconservatives imagine a future in which biotechnology has debased or eradicated us.

In the utopian scenario risks and unwanted side-effects are hardly recognized; if there are any, they will be remedied through better technology, is the belief. The goals of enhancement and improvement of human lives, individual well-being or health, and the advantages of the new technology for society at large are put central stage, while the possible negative effects are downplayed or simply ignored. Another strategy is to admit that there are risks but to claim that the advantages will in the end outweigh these risks, and that it is irresponsible not to experiment. "But that is what we mortals have done ever since Prometheus, the patron saint of dangerous discoveries. We play with fire and accept the consequences,

because the alternative is an irresponsible cowardice in the face of the unknown" (Dworkin, 1999).

In dystopian scenarios, on the other hand, the risks and dangers are the focus of attention, while the impression is being created that nothing good is to be expected from these new technological powers.

As a result of these opposing scenarios, much of the debate concerning new biotechnologies oscillates between two extreme positions: a utopian and a dystopian. In the first, risks and vulnerability are considered a reason for swift further technology development; in the second they are considered a reason to ban the feared technological developments altogether. This dichotomous way of discussing the future is not very fruitful in dealing with actual vulnerabilities and risks, or in developing strategies to deal with the uncertainties in this respect.

However, polarization is not inevitable. Section 3 discusses a recent turn in the debate on GMO's, from inherent characteristics of GMO towards issues of power and intellectual property. If this debate will be able to do justice to newly emerging complex social realities of GMOs, it could escape from entrenched polarizations. The debate is also promising from the point of view of societal agenda setting, as it strongly embeds technology within issues of justice and power relations.

6. Scenarios and storylines

The same criticism holds for a number of methodologies for imagining the future that are being used in policymaking and governance. A distinction can be made between *descriptive* methodologies that explore possible futures and normative (or *prescriptive*) methodologies that investigate possible pathways to a preferable future.

Prescriptive methods that nowadays are gaining in popularity are 'visioning' and 'roadmapping'. These methods represent forms of *backcasting*: the vioning and roadmapping process starts from a desirable future endpoint (e.g. the biobased economy) and outlines a series of steps to get there. Typically visioning and roadmapping are only about the future in the singular. Moreover, the road ahead is depicted as a linear and straight-lined.

As will be pointed out in section 2 in some detail, the entire roadmapping exercise focuses on identifying the possible technical and policy 'barriers'

for the realization of the goals, that are not up for debate themselves. Problems and critical objections are being absorbed into the programme by framing them as barriers to be overcome or challenges to be addressed. This notion of 'barriers' is also used with regard to public opinion, to prevent 'misconceptions' and resistance to the introduction of new technologies such as GMOs.

A descriptive method that has been prevalent for a long time is the explorative scenario study. This is a form of *forecasting*: exploratory scenarios seek to inform policy making by illuminating underlying drivers of change. They emphasise drivers, and do not specify a predetermined desirable end state towards which must storylines progress. An important feature of exploratory scenarios is that the storylines are not supposed to be driven by a preconceived desirable end-point. "However, many of the exploratory scenario studies include a 'happy ending' storyline… This suggests a tendency for such exercises to come up with an unconscious 'favourite'-one'" (McDowall & Eames, 2006: 1239).

Most scenario studies use a coordinate system consisting of two axes, thus combining two 'variables'. The first variable often concerns technological development (for instance: progress versus stagnation), while the second variable concerns the social context (e.g. individualism versus collectivism, or globalisation versus regionalisation). Thus, four futures are being created, structures by two dichotomous determinants. Such scenario studies show little imagination. The focus is on a limited number of possible futures, determined by a very limited number of variables. Moreover, continuity is the norm with linear developmental pathways and gradual changes and without radical shifts or trend-breaking developments (Asselt et al., 2003).

In short, most methods that currently came into fashion for imaging the future like visioning and roadmapping suffer from the dynamics of hype and promote a tunnel vision, which leaves scarce room for critical discussion and alternative options.

The fate of alternative options receives special attention in section 3. Approaches that build on local and traditional (low tech) knowledge are especially out of tune with today's dominant innovation climate, in which the settings are global, and social hopes and attention are focused on new technologies, controversial though they may be at the same time.

7. Actors and their interests

We should not ignore the fact that future forecasts and scenarios are formulated by particular actors who want to secure their interests and defend their present strategic choices (Bakker, 2003). In each instance the question, therefore, is which actors have had an influence on the forecasts and explorations and which actors have been excluded from participation. Section 2 shows that biofuels policy is framed in favour of certain vested interests in the automobile and truck industry. Visions and roadmaps formulated by industry-dominated advisory bodies will not explore the full range of possible futures but rather reflect a tunnel vision of select group of stakeholders.

In addition to Nik Brown's 'hope against hype' dilemma, we are confronted here with yet another dilemma. When a Vision or Roadmap is being formulated with a limited number of stakeholders, it is possible to "put all the noses in the same direction" and to get the various interests aligned in the same formation, but the end result will most likely be a tunnel vision. If the express purpose is to bring a small group of stakeholders together in a common strategic forum, as is the case in many 'roadmapping' exercises, then imaginative thinking and the 'opening up' of different possible socio-economic and technological futures will not be stimulated. Instead, the process will most likely lead to a 'closing down' of possible options on the basis of the set of interests that are represented in the confined forum.

This fits in with more general cultural observations. James Kennedy (2005) has pointed out that in the Netherlands the search for consensus in societal deliberation has a conspicuous side effect: general opinion tends to change, after a brief period of instability, rapidly and radically. Such changes look like massive conversions from one consensus (or "dogma") to the next. Very soon, a conversion is so complete that critical discussion is no longer taking place, which is why most observers from abroad find normal Dutch politics boring and superficial: until the next conversion it is just about filling in the details within a frame of consensus. One disadvantage of those collective breaks, according to Kennedy, is that collected experience and wisdom from the old dogma are thrown away, in order to make a completely fresh start. This amounts to "throwing away the child with the bathwater".

To avoid the formulation of a tunnel vision, one may try to involve and engage a much broader range of stakeholders, but then the risk is that one will end up with abstract and non-committal formulations that only suggest rather than truly express a shared vision, or as Dierkes *et al*. stated, "the

more general, broadly interpretable, and hence, noncommittal the formulation of the options for shaping technological development, the easier and quicker it is to establish broad consensus" (quoted in McDowall and Eames 2006, 367). Or, if the final formulations turn out to be somewhat less non-committal, it may lead to the departure of disgruntled powerful actors who do not recognize themselves in the conclusions – as happened with the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), where the biotech companies Monsanto and Syngenta eventually pulled out (Stokstad, 2008). A possible answer to the dilemma might be that in the process of policy preparation and policymaking a clear separation is introduced between the function of exploring possible futures and the function of creating social consensus and commitments. As Margo Trappenburg put it in one of her columns, "One should not create a base for social support, one should organize dissidence" ("Er moet geen draagvlak worden gezocht, er moet tegenspraak worden georganiseerd") (Trappenburg 2008).

2. Biofuels

1. Introduction: a cycle of hype and disappointment

Only a few years after many countries around the world decided to support the development and deployment of liquid biofuels for the transport sector as a major part of the desired transition to a more sustainable 'bio-based economy', the wisdom of this policy has already been called into question by many researchers, NGOs and national and international organizations. The suddenness of the apparent turnaround in opinion is remarkable. Yesterday biofuels were hailed as a welcome means to reduce carbon emissions and mitigate global warming, to lessen dependence on imported oil and, as an added bonus, to reawaken the economic prosperity of rural life. Today, biofuels are blamed for hitting the poor and hungry of the world by driving up food prices, causing deforestation and accelerated rates of biodiversity loss, aggravating global warming and not even making a serious contribution to saving fossil fuels. Within the interval of half a dozen of years, we seem to have gone through an entire "cycle of hype and disappointment, awe and loathing" (Brown 2003, 4).

The backlash in opinion seriously started when in early 2007 the Mexican tortilla crisis reached the headlines, providing a graphic illustration of the so-called 'food versus fuel' dilemma. There are a number of underlying causes for the rising trend in world food prices, but in news items on food riots the increased acreage devoted to the growing of crops for biofuels (though still a very small percentage of the total acreage of world agriculture) is consistently mentioned as an important contributory cause. The harsh choice between food and fuel is expressed in the following much-cited claim pertaining to the production of bioethanol in the US: "Filling the 25-gallon tank of an SUV with pure ethanol requires over 450 pounds of corn – which contains enough calories to feed one person for a year" (Runge and Senauer 2007).[1] In October 2007, UN's special rapporteur Jean Ziegler

[1] See also Ank Jansen's interview with Hans Eenhoorn: "One SUV tank with bioethanol made of corn can provide food for one person for a whole year." Jeffrey McNeeley, chief scientist of the IUCN, elaborates on the example: "The grain required to fill the petrol tank of a Range Rover with ethanol is sufficient to feed one person per year. Assuming the petrol tank is refilled every two weeks, the amount of grain required would feed a hungry African village for a year." (McNeeley 2006). In response to such figures, venture capitalist Vinod Khosla cites the findings from a Japanese study reported in *New Scientist* to argue that the trade-off is not so much between food and fuels as between basic food

even called the growing of crops for biofuels a "crime against humanity" (BBC Online, 27 October 2007). One month earlier, the OECD published a critical study entitled *Biofuels: Is the cure worse than the disease?* (Doornbosch and Steenblik, 2007), which questioned the wisdom of betting on a single technology. Negative publicity continued in early 2008, when new scientific studies reported that in many cases biofuels tend to aggravate rather than to curb the emission of greenhouse gases (Fargione et al. 2008; Searchinger et al. 2008). In January 2008, the Environmental Audit Committee of the British House of Commons criticized (UK and by implication European) biofuels policy as an "example of silo policy-making" that did not fit rationally with the rest of climate change policy. The Committee even wondered whether transport biofuels would have a long-term role to play at all, "[g]iven long-term demographic and climate change trends that might add further to food security problems" (House of Commons 2008, 33). Environmentalist and nature conservation NGOs, finally, point the finger to the increased (especially European) demand for palm oil as a source for biodiesel as the driving factor behind the accelerated deforestation in Malaysia and Indonesia, leading to the release of huge additional carbon amounts into the atmosphere and the loss of the remaining habitat for the orang-utan.

It would seem that an almost complete change in the public appreciation of biofuels in such a relatively short time interval deserves closer scrutiny. Why did they arouse such high expectations at first, only to be confronted with a severe backlash somewhat later? How could they make such a quick trajectory from being a panacea for the world's environmental and energy problems to the primary scapegoat for global injustice and glaring failures in conservation and environmental protection?

This part of our report aims to answer these questions and to draw some policy lessons from the biofuels saga.

In what follows we will first deal (in Section 2) with the methodologies (known as Life Cycle Analysis) that are used to determine the likely global effects of biofuels. The present controversies are hardly understandable

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supplies and expensive beef: "... it takes approximately 25 pounds of corn to put a pound of steak on your dinner table … a kilogram of beef is responsible for the equivalent of the amount of CO2 emitted by the average European car every 250 kilometers, and burns enough energy to light a 100-watt bul for nearly 20 days" (Khosla 2007a, 8-9). "If replacing gasoline is not an acceptable usage of corn, does eating unhealthy steak qualify? What is more critical to society – a gallon of ethanol or a pound of steak?" (ibid., 8).

without entering into some of the technical intricacies of these assessment techniques. It is notable that the push for biofuels had already started before a full-fledged scientific assessment framework was in place.

In Section 3 we deal with the meta-narrative of the coming 'bio-based economy' (or 'bio-economy'). Expectations about biofuels are usually embedded in a broader vision that we are involved in a *transition* from an economy based on fossil energy towards a 'bio-based economy'. In dominant versions of this meta-narrative there is a strong faith in scientific and technological progress and a pronounced rhetorical tendency to 'naturalize' biotechnology and other advanced technologies so as to suggest their inherent compatibility with Nature. Our analysis of the latter aspect has been inspired by the work of the German philosopher Joachim Schummer on similar 'naturalizing' tendencies in popular accounts of chemistry.

Section 4 and subsections 4a and 4b look more closely at the official 'visions' and 'roadmaps' about the 'bio-economy' in general and about biofuels in particular that have been formulated by groups of experts and stakeholders in the USA and the EU. Their efforts, it turns out, have not been aimed at an open exploration of a wide range of possible futures. What seems to have occurred in both the USA and Europe is an early closure on a particular future that looked attractive to the small circle of stakeholders involved. The 'visions' and 'roadmaps' on the 'bio-economy' and especially on biofuels thus exhibit characteristic shortcomings: a linear, technological-determinist view of the future in which a 'roadmap' pictures just a straight, one-way street toward the final destination as formulated in the 'vision'; a strong faith in scientific and technological progress; a typical framing of problems that may occur as just so many challenges to be addressed or barriers to be overcome. The linear roadmaps show a quasi-natural succession of different 'generations' of biofuels, where the present 'first generation' will be followed by a 'second generation' (and in some accounts even by a 'third' and a 'fourth'). The idea of inevitability implicit in technological determinism becomes manifest when proponents assert that no generation can be skipped: earlier generations are necessary as 'stepping stones' or 'gateways' for the later generations.

Section 5 looks critically at the social and political processes by which 'tunnel visions' are generated through a more detailed examination of how and especially by whom the official roadmap for biofuels in the EU has been formulated. We discuss the critical brochures that the US-based Clean Air

Task Force and the European-based Corporate Europe Observatory have issued on this subject.

In Section 6 we look at the visions about the future that are held by two private actors, venture capitalist Vinod Khosla and scientist and 'bio-entrepreneur' J. Craig Venter, who are willing to invest their money and their efforts in realizing next-generation biofuels. This complements our analysis of the visions and roadmaps formulated by semi-official bodies. The visions of these private 'entrepreneurs' embody the same (or even more strongly) optimistic assumptions about scientific and technological progress as the semi-official views. It is, however, something different when individual entrepreneurs act on certain hopes and expectations or when public policy is pinned on them.

The concluding Section 7 draws out some policy lessons for dealing with the 'hype versus hope dilemma'. We explore ways to make technology policy more hype-resistant. Following Margo Trappenburg, we argue for the urgent need to organize dissidence and solicit counter opinion rather than the customary attempts to create consensus and organize social support. Referring to Alfred Nordmann's work on nanotechnology and the very remarkable European response to the US NBIC initiative, we also point out that the intellectual tools for resisting hypes are already available. The only challenge is to use them.

2. A preliminary note on life cycle analysis

As biofuels have become a rather controversial topic in the last few years, scientific analyses and assessments that support or criticize the expansion of crop cultivation for the production of motor fuels have themselves become bones of contention. We will delve somewhat more deeply into the areas of controversy and the underlying reasons for scientific disagreement. It turns out that both the EU and the USA have already committed themselves to facilitating the introduction of (first-generation and next-generation) biofuels by means of subsidies, tax breaks, mandates (quota) and infrastructural measures *before* any sophisticated methodologies and frameworks for evaluating the *global* effects of these measures are in place. In the absence of such methodologies, both sanguine optimism (among the supporters of biofuels) and deep pessimism (among the critics) about the effects of the large-scale deployment of biofuels have free play.

Biofuels are promoted as sources of renewable, clean and sustainable energy that will lessen our dependence on fossil energy (especially

imported oil) and diminish greenhouse gas (GHG) emissions into the atmosphere. This immediately suggests some important metrics to assess their effectiveness, to wit, their net energy balance, the reduction of petroleum use, and the reduction of GHG emissions. Other relevant performance metrics relate to different environmental indicators such as soil erosion and water usage and pollution and to the possible displacement of food production ('food versus fuel').

Biofuels would obviously be a non-starter if they did not pass the first hurdle of a positive net energy balance. However, even a seemingly straightforward task as determining the net energy effect of a particular biofuel turns out to be immensely complicated. As Farrell *et al*. write, "calculations of net energy are highly sensitive to assumptions about both system boundaries and key parameter values" (Farrell et al. 2006, 506). This is illustrated in the spread of outcomes shown by various American studies measuring the energy return of investment for corn (maize) ethanol. Two critical analysts, David Pimentel and Tad Patzek, are well-known for their finding that corn ethanol actually has a *negative* energy balance: "To produce a liter of ethanol requires 29 % more fossil energy than is produced as ethanol …" (Pimentel and Patzek 2005, 66). With this negative outcome they stand rather isolated; other researchers have found at least *positive* yields (Hammerschlag 2006). These differences derive from different estimations of key parameters and different decisions about what to include among the types of energy inputs (Pimentel and Patzek included, for instance, the personal energy consumption by labourers and the energy costs of capital equipment, which other researchers excluded). A survey of studies commissioned by the Natural Resources Defense Council therefore decided to dismiss the negative finding of Pimentel and Patzek as simply an "outlier" (NRDC 2006). It is however doubtful whether this somewhat arbitrary Solomonic judgment does full justice to the matter at issue. Some commentators have argued that in practice net energy calculations tend to seriously *overestimate* the energy yield, because many small energy inputs have to be ignored for practical reasons but may nevertheless add up to a sizable total (Santa Barbara 2007, 6). Enthusiasts for biofuels, of course, are not likely to err on the side of caution, and there is ample room for tweaking the numbers: "Almost every lifecycle analysis is missing something. When the differential is 30 or 40%, it's easy to play with the statistics to push the number to the positive or negative side" (John Sheehan, quoted in Schubert 2006, 783).

A more radical criticism asserts that current Life Cyle Analyses (LCAs) of the impacts of biofuel use, which are simple extensions of net-energy analysis,

are inherently unsuitable to address their global effects such as the impact on global climate change (Delucchi 2004). Current LCAs are geared to answer narrowly circumscribed questions like what would happen if we replaced a distinctly defined 'petrol lifecycle' with a 'fuel F lifecycle', *with no other changes occurring in the world* (*ibid.*, 6). This excludes any consideration of *indirect* (often market-mediated) effects. In the real world, however, there would be no way to avoid such indirect effects. To trace them out and assess their cumulative impact, you need to have a sophisticated model of the global economy (representing what economists would call 'general equilibrium analysis'). The effects of the cultivation of crops for biofuels production would ripple through the global economy and the global ecology via changes in prices and consequent land use changes: "The indirect GHG emissions of biofuels produced from productive land that could otherwise support food production may be larger than the emissions from an equal amount of fossil fuels […]. Thus, indirect effects bring into question all current biofuel production pathways and many of those that are being developed." (Kammen et al., 2007, 6-7).

In early 2008 *Science* magazine published two scientific studies that attempted to quantify the indirect effects of the use of biofuels on GHG emissions (Fargione et al. 2008; Searchinger et al. 2008). Their findings were rather discomforting. The problem is the conversion of relatively undisturbed ecosystems like rainforests, peat bogs, savannas or grasslands into croplands. Such ecosystems store in their soils and aboveground biomass huge amounts of carbon, of which a large part will be released into the atmosphere when conversion to cropland occurs. The clearing of these ecosystems for the production of biofuels thus creates a 'carbon debt' of greater GHG emissions than the fossil fuels they replace. The conversion of peatland rainforests in Indonesia and Malaysia for the production of palm biodiesel, for example, creates a carbon debt that would take more than 420 years to repay by means of reduced GHG emissions due to the displacement of fossil fuels. Similarly, conversion of tropical rainforest in Brazil for the production of soybean biodiesel would create a carbon debt of 320 years. Even the clearing of central grasslands in the US for the production of corn ethanol would incur a carbon debt of 93 years (Fargione et al. 2008). Thus, for many decades or even centuries the problem of GHG emissions would get worse before starting to improve. Whereas the study by Fargione *et al.* focused on the increased GHG emissions due to land conversion, the study by Searchinger *et al.* concentrated on the indirect effects of expanding the area of biofuel crops. They calculated that a planned increase of US corn ethanol production of 56 billion liters in 2016, diverting 12.8 million ha of US cropland from food and feed production and

inducing the cultivation of an extra 10.8 million ha of land elsewhere in the US and on other continents, would nearly double GHG emissions over 30 years and increase greenhouse gases for 167 years. They thus conclude: "Use of good cropland to expand biofuels will probably exacerbate global warming in a manner similar to directly converting forest and grasslands" (Searchinger et al. 2008, 1240).

The findings of these studies, and especially of the Searchinger study, have been severely criticized by the Biotechnology Industry Organization and the New Fuels Alliance, industry groups with an important stake in biofuels production. The study by Searchinger *et al*. is accused of underestimating the possibilities of technological progress (e.g. expected increases in corn yields), of making worst-case scenarios and of using historical data series that no longer reflect present and future potentials. This line of criticism shows once more how technological optimism is characteristically pitted against technological pessimism or skepticism. Another point of criticism is that the inclusion of indirect effects like land use changes would necessitate the use of "very complex econometric models" (BIO 2008). It may be readily conceded that the model used by Searchinger *et al*. represents a first, still rather primitive and imperfect attempt to include indirect effects. However, both the Biotechnology Industry Organization and the New Fuels Alliance suggest that we should cling to Standard Life Cycle Analyses (which exclude consideration of indirect effects) because we do not have the sophisticated models to adequately deal with land-use changes (BIO 2008; New Fuels Alliance 2008). This response actually amounts to turning a blind eye to such indirect effects, perhaps in the hope that they will not be there if we don't look for them.

There is still another way to dispute the attribution of increased GHG emissions to the expansion of biofuels. The Biotechnology Industry Organization puts the responsibility for averting possible negative effects of increased biofuels production into the hands of governments: "Indirect land use changes are a function of land use policy. Sustainable biofuels production must go hand-in-hand with sustainable land use policy" (BIO 2008). In other words, it is up to the governments of Brazil, Indonesia or Malaysia to prevent that the pressure on land to meet the increased demand for biofuel and food will lead to further deforestation. Actually, this particular point had already been addressed by Searchinger *et al*.: "Effective controls on land conversion would constrain the major source of new supply to meet increased biofuel demands, resulting in less additional cropland and higher prices as markets seek equilibrium. *In that event, more greenhouse benefits would stem in reality from reduced food*

consumption" (Searchinger et al. 2008, 1240; our italics). The simple truth is that using land for the growing of biofuel crops competes with using land for food production or keeping it as forest or wilderness areas. This competition can be avoided by biofuels from waste streams and from perennials on degraded farmland or from algae grown in the desert (there is not much carbon in the desert). The scope for such possibilities appears rather limited. At any rate, all biofuels are not created equal and should not be tarred with the same brush.

The fact remains that biofuels are currently being promoted on the grounds of their presumed contribution to the reduction of GHG emissions, among other reasons, but that the methodologies and conceptual frameworks for assessing their actual impacts on global climate change, energy supply and food production are not yet ready.[2] In this sense the current push for biofuels is a leap into the dark.

3. The meta-narrative of the 'bio-based economy'

Looking back to the first years of the new millennium, it is not too difficult to understand why the times seemed to provide a strategic "window of opportunity" for a renewed push for biofuels (for earlier periods in which 'gasohol' and other biofuels attracted attention, see Bud 1994 and Finley 2004) . There was increasing recognition of the dire consequences of global warming and its anthropogenic causation as well as concern about the long-term availability of energy and the reliability of its supply from politically turbulent regions. The unwillingness of the US Republican government to seriously discuss any proposal for dealing with these global problems that might be seen to compromise the "American way of life", even in the slightest respect, was also a factor of some importance. The effect was that potential solutions had to come from new advances in technology.

A renewed push for biofuels fits into the broader concept of a 'bio-economy' or 'bio-based economy'. A website on the 'bio-based economy' maintained by EuropaBio and ESAB states that this term "encapsulates our vision of a future society no longer wholly dependent on fossil fuels for

[2] This point is also admitted by two severe critics of the Searchinger study: "At this time, it is not clear what land use changes could occur globally as a result of U.S. corn ethanol production. While scientific assessment of land use change issues is urgently needed in order to design policies that prevent unintended consequences from biofuel production, conclusions regarding the GHG emissions effects of biofuels based on speculative, limited, land use change modeling may misguide biofuel policy development" (Wang and Haq 2008, 3).

energy and industrial raw materials … The whole world is now in transition from the Age of Chemistry to the Age of Biotechnology." (www.bio-economy.net).

In 2001 the OECD issued a 'primer' or brief report on the application of biotechnology for the realization of industrial sustainability, which was based on a more extensive document (OECD n.d. [2001]). This report is a prime example of the new meta-narrative of the 'bio-based economy'. It exemplifies a characteristic faith in the possibilities of scientific and technological progress. It also exhibits certain remarkable narrative themes and storylines, which are very similar to the ones that the philosopher Joachim Schummer extracted from popularizing literature about chemistry (Schummer 2005). The net effect of these themes and storylines is a rhetorical 'naturalization' of biotechnology and other advanced technologies.

Sustainability, according to the OECD report, entails a *decoupling* between economic growth and environmental deterioration:

> "The aim is to uncouple economic growth from environmental degradation so that industry will be more profitable and, simultaneously, environmental quality will also improve" (OECD n.d. [2001], p. 7).[3]

This sets the task for industrial biotechnology. In order to realize an annual economic growth of 4 %, the 'eco-effciency' of new production technology must be, as the report shows, three to four times as good as that of existing technology if the 'environmental footprint' is to remain at least constant (*ibid.*, p. 9; explanation below graph). Based on a number of case studies from various business sectors, the report concludes that this task is in principle feasible and realistic under a range of boundary conditions. The

[3] The BIO4EU study commissioned by the European Parliament also claims that several applications of modern biotechnology (e.g. bioethanol) "address challenges such as global warming and security of energy supply and *provide an opportunity to break the link between economic growth and pressure on the environment*" (Zika et al. 2007, 9; our italics). However, the report does not give much evidence to support this remarkable 'linkage-breaking' claim. In a critical commentary on the BIO4EU study, BioscienceResource.Org notes a "spectacular disconnect between its bold visions and its practical examples" and asserts that the vision of a knowledge-based 'bio-economy' is "not so much a real and substantial prospect but more a fantasy future – one designed to meet present political needs for envisioning sustainability without at the same time abandoning a belief in technological 'progress'." (BioscienceResource.Org, 2007, 7).

strategic vision of a 'bio-based economy' is thought to provide guidance to facilitate the transition to a (more) sustainable mode of production:

> "The bio-based economy uses renewable bio-resources (agricultural, forestry and marine) and eco-efficient processes (including bioprocesses) to produce sustainable products, jobs and income" (ibid., p. 17 footnote).

In this connection the use of biofuels (and more generally of biomass) is specifically mentioned. However, the report holds that the transition toward a 'bio-based economy' will not occur spontaneously – the new 'green revolution' involves a veritable paradigm shift demanding deliberate guidance and coordination. In this connection the report refers to the 'Vision' and 'Roadmap' for 'Plant/Crop Based Renewable Resources', which have been formulated in the US in 1998 and 1999 (meanwhile several yearly updates of these 'Visions' and 'Roadmaps' have become available).

The reassuring overall message is, of course, that science and technology will solve our problems:

> "[…] advances in science and technology are making it possible to have an economy where industrial development and job creation are not in opposition to environmental protection and quality of life" (ibid., p. 18).

It is true that the report duly notes that "getting there will be a major challenge", but optimism sets the tone. The OECD report professes its faith in scientific progress and simply expects that science and technology will enable continued economic growth without degrading the environment any further. To avoid possible misunderstandings about the ultimate aims, the report quotes from Shell's annual report for 2000: "Excellent environmental performance is meaningless if no wealth is created" (ibid., p. 6).

Under the heading 'Learning from Nature: Biomimicry and Biotechnology', the OECD report describes a number of approaches that could help bring about the desired paradigm shift. This description is amenable to the same kind of rhetorical analysis that Joachim Schummer performed with regard to the storylines and 'meta-narratives' contained in popularizing literature about chemistry (Schummer 2005). According to Schummer, this literature builds on older representations of the relationship between man and nature that are to be found in alchemistic treatises. These are schematized in the following Table:

Table 1: Alchemy-nature relationships in alchemical treatises

Typical phrases	*Nature's role as quasi-person*
Alchemy imitates / learns from nature	Teacher
Alchemy competes with / rivals nature	Rival
Alchemy surpasses / improves upon nature	Inferior
Alchemy dominates / masters / defeats nature	Dominated

Schummer shows that in writing popular stories about the development of their discipline chemists adopted the alchemist schema about possible relationships vis-à-vis Nature (considered as a quasi-person), but gave a *diachronic* twist to it. By putting the set of possible relationships into a chronological order, a developmental path is suggested which places the day-to-day activities of researchers into the perspective of a meta-narrative and thus grants metaphysical meaning and orientation to them. Such a perspective is for example provided by Paul Walden's *Geschichte der Organischen Chemie seit 1880* (Berlin, 1941). At the outset, Nature is the chemist's teacher and the chemist tries to learn from her by imitating her. In the next stage, the chemist is no longer Nature's pupil but her rival or competitor, who in many cases is capable to equal her achievements. Somewhat later, the chemist proves to be superior to Nature and capable of surpassing the quality of her products. The meta-narrative ends with a prospect on the chemistry of the future which will be able to master and control Nature: "chemistry will begin to direct, in accordance to their conditions, the processes in the living organism and to design them for the benefit of humanity" (quotation from Walden).

Schummer then describes how the same narrative scheme was also followed in American popular accounts of chemistry that appeared during the postwar period. Invariably the chemist, or chemistry, was portrayed as engaged in a struggle with Nature. However, this created public image turned into a major liability when the environmentalist movement emerged in the wake of Rachel Carson's writings. In 1976, at the request of the American Chemical Society, John Woodburn therefore wrote a new popular introduction to chemistry, *Taking things apart & putting things together* (Washington, 1976). Woodburn varied on the received themes in a rhetorically subtle way, such that the story was no longer about 'chemists versus nature'. Instead of 'nature' he started to write about 'nature's chemistry': "Nature's chemistry is never turned off. [..] Nature's chemistry is fantastically successful. [..] is fascinating". Moreover, rather than talking about 'chemists' he was just relating the pursuits of 'people'. Eventually, Woodburn suggested, 'people' would not be content simply to admire

'nature's chemistry': "People want a piece of the action; they want to be free from blind dependence on nature's chemistry. They want to progress, to make better use of or even go beyond nature's chemistry." So Woodburn too sketched a transition from imitation and admiration of nature towards the attempt to rival and surpass nature (or rather 'nature's chemistry'). But by changing the names of the characters in the cast ('people instead of 'chemists'; 'nature's chemistry' rather than 'nature') he could considerably soften up the traditional meta-narrative. Deleting the fourth and final stage, the mastery and domination of nature, from the story also helped to soften it.

Reports on the prospects of chemistry and its sub-disciplines or related fields like biotechnology and nanotechnology, commissioned by professional associations or governmental agencies, often elaborate and vary on the same narrative elements. Thus the Pimentel report from 1987 mentioned "controlling nature's biotechnology" as the goal of recombinant DNA technology: "scientists are learning to alter the actual blueprints so nature's factory will make a new substance that was not in its product line before".

Back to the OECD report. What is striking in the section entitled 'Learning from Nature: Biomimicry and Biotechnology', is that the narrative theme of 'learning from nature' almost imperceptibly changes over into what at first sight would seem to be the opposite motive of the 'domination of nature'. The text suggests that the latter is just an elaboration of the former and that (industrial) biotechnology is a continuation and extension of 'biomimicry' (the title of the section explicitly suggests that 'biomimicry' and 'biotechnology' both fall under the overarching idea of 'learning from nature'). After noting that a paradigm change will be needed to obtain the fourfold improvement of 'eco-efficiency' required for industrial sustainability, the report continues:

> "For a growing number of companies, the inspiration for such a paradigm shift is coming from the products and processes found in natural ecosystems and the organisms that live in them. Biomimicry is the name coined for this approach in which industrial production systems imitate nature. Industrial biotechnology is that set of technologies that come from adapting and modifying the biological organisms, processes, products and systems found in nature for the purpose of producing goods and services." (OECD n.d.. [2001], p. 10).

It thus seems that only a very small step is required to make the transition from the 'imitation of nature' to 'adapting and modifiying' its products and processes.

'Industrial ecology' is mentioned as one instance of an approach that imitates nature. Natural ecosystems are set as examples that industry has to emulate because here all the energy used is 'renewable' and the 'bio-organic chemicals' are also renewable and biologically degradable and are effectively recycled: "There is no such thing as 'waste' – the by-products of one organism are the nutrients for another." (OECD n.d., p. 10).[4] 'Industrial ecology', then, is defined as follows:

> "Groups of companies can mimic the co-operative action of organisms in natural ecosystems by clustering around the processing of a feedstock such as biomass so the by-product of one is the starting material for another. Also, energy, such as waste heat, can be used efficiently. This approach is called 'industrial ecology'" (OECD, n.d., p. 11).

Another example of imitating nature that is mentioned in the OECD report is the so-called 'molecular evolution', through which the performance of naturally occurring enzymes can be improved by artificially imitating the process of mutation and selection in the form of a succession of genetic modification and high-throughput screening. There is indeed a formal similarity with the processes of natural evolution (not unlike for other developments in science and technology, which can also be described analogically as an interplay of 'mutation' and 'selection'), but that by no means diminishes the fact that this type of operation represents a rather intensive mode of technical interference.

This is even more so the case with a technique called 'metabolic engineering', where it would be even less plausible to claim that it only imitates nature:

> "The metabolic pathways of micro-organisms can also be modified by genetic engineering. The aim is to turn each cell into a highly efficient 'mini reactor' that produces in one step and at high yield what would take an organic chemist a number of steps with much lower yield […]" (OECD, n.d., 11).

A lay person would certainly not consider a 'mini reactor' to be a familiar part of the furniture of nature.

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[4] We wonder whether it is meaningful at all to speak of 'waste' in the context of natural ecosystems: isn't this a case of projecting a normatively loaded, human-related concept – 'matter out of place', to cite Mary Douglas's definition – onto nature? Or at least it seems that nature is first being looked at through technological spectacles and then set as an example for technology to emulate.

An entire series of techniques and technologies are brought under the umbrella of the 'bio-based economy', but only a small subset of these can legitimately pretend to imitate nature. Other technologies like 'metabolic engineering' and industrial biotechnology are mentioned in the same breath, apparently in the hope that the favorable green image will also reflect on them. Actually, it is quite doubtful whether the alleged differences between 'imitating nature', 'surpassing nature' and 'controlling nature' are relevant at all for the normative assessment of different technologies.[5] The OECD report could have confined itself to the potential contributions of different technologies to the realization of sustainable modes of production.

The OECD report is exemplary for the more widely shared meta-narrative on the transition towards a future 'bio-economy' or 'bio-based economy'. In this meta-narrative there is a strong will to believe that by deploying advanced technologies (like biotechnology, nanotechnology, genomics, synthetic biology etc.) continued economic growth can be realized without further deterioration of the environment. The tendency is to err on the side of optimism rather than on the side of pessimism. Critical scrutiny is further discouraged by the rhetorical use of the positive connotations of the pre-fix 'bio' (as in 'bio-mimicry') and other forms of 'naturalizing' human interference, which suggest that the new technologies are automatically in harmony with Nature but which do not guarantee that our ecological footprint will be sufficiently reduced to allow further economic growth.

4. Visions and roadmaps

The USA and the European Union, as well as the OECD and other countries, have set up various groups of experts and stakeholders to work out scenarios for the coming 'bio-based economy'. These groups have been regularly engaged in formulating 'visions' and 'roadmaps' both for the 'bio-based economy' as a whole and for bioenergy and/or liquid biofuels in particular. Today, 'visioning' and 'roadmapping' (indeed, the two words can

[5] In a sense, control over nature is inherent to any technology. 'Biomimicry' can also be seen as a form of mastering nature. Significantly enough, the herald of the age of technology, Sir Francis Bacon, did not worry much about the differently loaded connotations connected with terminological differences like that between imitating and mastering nature: "I do not much care for such fancy ideas and pretty words. I intend and mean only that nature, like *Proteus*, is forced by arts to do what would not have been done without it; and it does not matter whether you call this forcing and enchaining, or assisting and perfecting." (Bacon, quoted in Pesic 1999, p. 86).

be read as verbs referring to activities!) are routinely undertaken to engage relevant industrial and scientific-technological stakeholders in formulating a shared vision of a desired future state (say, around 2030) and an associated time schedule with intermediate steps for getting there, so as to elicit and strengthen their commitments in helping to actualize the envisioned future. What we see here is a point that is rightly stressed in the sociology of expectations: scenarios do not just *explore* the future; they also have an important *performative* aspect. They create expectations that mobilize and sustain efforts aimed at realizing particular futures. This performative aspect is especially strong for 'visions' and 'roadmaps'.

In next two subsections we will look more closely at how these modes of forecasting have been practised in the USA and the EU, respectively, to formulate shared futures on the 'bio-based economy' in general and, especially, on biofuels in particular. In both cases, only small circles of industrial and scientific stakeholders have been involved in the relevant visioning and roadmapping exercises. This limited participation may have been instrumental in getting all involved lined up in the same formation ("to put their noses in the same direction"), but it may also have led to the generation of tunnel visions. It is no wonder, then, that the policy documents that are the outcomes of these efforts exhibit a whole series of characteristic limitations and shortcomings such as a constrained framing of the underlying problems, unwarranted scientific and technological optimism, and a rather technocratic approach towards problems of implementation.

4a. Visions and roadmaps in the USA

Two reports document the main outcomes of the American attempts of visioning and roadmapping in the area of the bio-economy in general and of biofuels in particular:

(1) Biomass Research and Development Initiative (BR&Di), *Vision for Bioenergy and Biobased Products in the United States: Bioeconomy for a Sustainable Future:* 2006.

(2) Biomass Research and Development Technical Advisory Committee / Biomass Research and Development Initiative, *Roadmap for Bioenergy and Biobased Products in the United States*: October 2007.

The two documents derive from the same committee, the Biomass Research and Development Technical Advisory Committee, which was installed in 2000 in pursuance of the *Biomass R&D Act*. In what follows we will refer to

these documents as Vision 2006 and Roadmap 2007. The latter also takes account of the recommendations which had been made during the regional Roadmap Workshops in the western, central and eastern regions of the USA. Vision 2006 is an update of the first 'Vision' published in 2002.

Each year the committee's membership varies slightly. In 2006 some 11 members came from industry, 2 from the government, 4 from academia and 1 unknown (Vision 2006, see Table in executive summary). A quick scan shows that participation in regional Roadmap Workshops is also dominated by representatives from industry.

'Vision statement':

> "By 2030, a well established, economically viable, bioenergy and biobased products industry will continue new economic opportunities for the United States, protect and enhance our environment, strengthen U.S. energy security, provide economic opportunity, and deliver improved products to consumers" (Vision 2006, executive summary; probably quoting Vision 2002).

The tone is striking. True, the environment (or, somewhat chauvinistically, '*our* environment') is not forgotten, but what seems to come first is the need to exploit new economic opportunities (even to the extent that the term 'economic opportunity' figures twice in the quoted passage, in singular and in plural form, and the expression 'economically viable' is also used). Another important aim is energy security, which is also explicitly related to the strategic and military security of the US, as the rest of Vision 2006 shows.

Vision 2006 "defines a set of achievable quantitative tools to help the United States transition from a fossil-fuel-based economy to a biobased economy" (Vision 2006, 1). For that purpose the Committee formulated what it calls "aggressive goals" in terms of market shares and physical consumption for biofuels and biopower and for the consumption of bioproducts in the years 2010, 2020 and 2030. These goals are supposed to function as benchmarks which enable to measure the progress being made toward realizing the 'Vision statement' for 2030 (Vision 2006, executive summary). In addition, Vision 2006 added interim targets for the year 2015.

For biofuels the goals set for the targeted market shares in the years 2010, 2015, 2020 and 2030 are: 4%, 6 %, 10 % and 20 % (starting from 1.2 % in 2004). For biopower the targets are: 3.1 %, 3.2 %, 3.4 % and 3.8 % (starting from 2.1 % in 2004). For bioproducts there is an indication of steadily rising

volumes in terms of billions of tonnes, from 17.5 billion lbs in 2004 to 55.3 billion lbs in 2030.

In a section about 'Energy diversity and security', Vision 2006 explains that the US energy supply is extremely vulnerable due to the one-sided dependency on oil and natural gas:

> "The United States has only 4 percent of the world's population but consumes about 25 percent of the world's produced oil" (Vision 2006, 4).

Quite significantly, this fact is framed here from the concern about energy security. One could however highlight the same numerical fact from the angle of global justice to stress that Americans claim a disproportionate share of the world's fossil fuels (and therewith of the atmosphere's capacity to absorb greenhouse gases).

No detailed argumentation is given in Vision 2006 to justify the mentioned targets, apart from an estimation of the total amount of available biomass in the US (1.3 billion tonnes) and the intention to encourage the transition towards the bio-economy by setting "aggressive goals". In his State of the Union Address of 2007, President Bush upped the ante still further by also setting an "aggressive goal", namely that by the year 2017 20 % of petrol consumption must have been replaced ("Twenty in Ten"). The Committee decided to subscribe to the President's ambitious plan, because it pointed in the same direction as its own proposals, even though it was "an even more aggresive goal for biofuels than the Committee's Vision" (Roadmap 2007, executive summary). It therefore added "key recommendations" on policy priorities to Roadmap 2007 in order to help realize the presidential plan. These supplement the other technical and policy strategies set out in the Roadmap.

The goals themselves are not up for debate. The entire roadmapping exercise, with the involvement of the Regional Roadmap Conferences, focuses on identifying the possible technical and policy 'barriers' for the realization of the quantitative goals for biofuels, biopower and bioproducts and on making suggestions on how to overcome them. The adopted approach, with its special emphasis on the key notion 'barriers', entails that problems are being framed in a rather specific way. Barriers are only there to be overcome; problems that present *insurmountable* barriers for the realization of the targets have been excluded by definition. That at least seems to be the implicit logic of the entire exercise. All the 'barriers' discussed in Roadmap 2007 are therefore just so many "challenges" or

"issues to be addressed" (see also McDowall and Eames on the rhetoric of hydrogen future scenarios).[6] Objections made by critics can always be reformulated as "challenges" and absorbed into the programme.

The following passage provides an example of this tendency:

> "Nutrient loss from soil and soil contamination are *major challenges* facing increased demand for biomass feedstocks. For example, growers need to learn how to make more efficient use of nitrogen. In addition, there is a lack of data on the limits of removal of residual biomass and whether or not it will ensure sustainability. The availability of sufficient arable land and water resources *are issues that must be addressed* (Roadmap 2007, 10; our italics).

We speculate that this 'framing' of problems as just so many challenges to be addressed or barriers to be overcome and the setting of "aggressive" goals as a dominant style of policy-making may easily tempt politicians to conceive of their role as consisting in proclaiming even more "aggressive" goals and thereby gaining a can-do reputation. After all, if barriers are only there to be overcome, then goals can never be too "aggressive" and ambitious. That is why President Bush further raised the targets and the Committee had no choice but to comply.[7]

The concept of 'barriers' is also used with regard to public opinion. 'Misconceptions' that the public might hold about biofuels are treated as a

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[6] "[…] many of the descriptive futures appear to display a pro-hydrogen bias, as is clear from the way that barriers to a hydrogen transition are considered. For example, the difficulty of storing hydrogen, a function of its low mass, is framed not as a disadvantage, but as a technological 'challenge'." (McDowall and Eames 2006, 1247).

[7] Not all American politicians have been persuaded to support subsidizing biofuels. In November 2003 Senator John McCain showed his defiant independence by making the following statement: "Ethanol is a product that would not exist if Congress didn't create an artificial market for it. No one would be willing to buy it. Yet thanks to agricultural subsidies and ethanol producer subsidies, it is now a very big business – tens of billions of dollars that have enriched a handful of corporate interests – primarily one big corporation, ADM [=Archer Daniels Midland]. *Ethanol does nothing to reduce fuel consumption, nothing to increase our energy independence and nothing to increase air quality*." (McCain 2003; our italics). Since then, however, McCain has backtracked from this firm position, which was a political liability in the US election campaigns given the crucial role of Iowa and other 'swing' states in the Corn Belt. In August 2006, McCain declared: "I support ethanol and I think it is a vital, a vital alternative energy source not only because of our dependency on foreign oil but its greenhouse gas reduction effects." (Quoted in Birger, 2006). In contrast to the platforms of Barack Obama and Hilary Clinton, however, McCain opposed the use of subsidies and governmental mandates.

non-technical barrier that must be addressed by a purposive campaign or "a concerted effort" (Roadmap 2007, 38). Public consultation to raise public awareness thus threatens to become a one-sided PR offensive, as transpires for example from one of the key recommendations for realizing the Presidential "Twenty in Ten' programme:

> "The Federal government needs to develop a comprehensive communications and outreach program that creates an industry/government voice to support the aggressive market goals of 'Twenty in Ten'; such a program should focus on developing consumer and industry awareness, reducing barriers resulting from lack of understanding, and addressing misperceptions on issues such as net energy balance, impact on food prices, and net cost of subsidies to government." (Roadmap 2007, 7).

Efforts should also be undertaken to eliminate possible public resistance against the use of GMOs. Under the heading of "GMO Acceptance' Roadmap 2007 states the following:

> "Education and collaboration efforts are needed to overcome GMO-related barriers. Environmental advocacy organizations must become partners in the effort of the biomass industry to help the U.S. achieve less dependence on fossil fuels. The biomass industries and scientific community should work together with environmental organizations and communities concerned about GMOs to help educate them." (Roadmap 2007, 34).

It is highly doubtful whether environmentalist groups will acquiesce in being put before this cart and fulfil the role assigned to them; after all, they had no share in formulating the Vision and the Roadmap.

The Committee and the participants of the Roadmap Conferences would like to see everybody lined up in the same formation. They deeply regret the lack of an "industry champion" who could make industry speak with one voice (cf. Vision 2006, 16):

> "One factor contributing to lack of consumer awareness is the absence of a single voice to represent the industry. Biomass industries and technologies are diverse, so while there are many industry organizations, associations, and others speaking on behalf of particular aspects of the industry, there is no spokesperson for the industry as a whole. This can lead to fragmented efforts to promote bioenergy, overcome ineffective policy, and educate consumers." (Roadmap 2007, 14).

It is also noted that there is not really a "long-term national commitment to biomass R&D" and that policy is often arbitrary and capricious so that industry is reluctant to make long-term investments:

"The short-term nature of energy policy and changing focus on favored energy resources and technologies has created a disincentive for industry to make long-term investments in new technology and research." (Roadmap 2007, 13).

In the 'key recommendations' to realize the 'Twenty in Ten' programme the Committee takes an example from President Kennedy's space programme aimed at landing a man on the moon before the closing of the 1960s:

"The government should begin a significant national initiative, reminiscent of the space program of the 1960s to land the first man on the Moon, to ensure that the needed infrastructure, human resources, research and development support, and policies are in place to enable the level of growth in biomass-based fuels, products, and power as proposed by the President and as contained in the Committee's Vision statement." (Roadmap 2007, 6).

It would seem to us that the comparison does not hold. The 'Vision statement', comprising quantitative goals for biofuels, biopower and bioproducts, is rather different from such a concrete goal as getting the first man on the moon. It is significant, however, that one falls back on this classic example of directed and focused R&D planning.[8]

Elsewhere the Roadmap returns to this idea and expresses the following hope:

"It [the initiative] should seek to reduce the level of congressionally directed funding that does not contribute to national energy goals" (Roadmap 2007, 36).

In all likelihood this will be an idle hope; US Congress is not going to cooperate on a scheme to neutralize its role. The wish to circumvent politics in the usual sense betrays a rather technocratic vision.

[8] In March 2007 Senator Barack Obama also referred to the Apollo project as an example for US biofuels policy: "Twenty years from now our nation's transportation fuels sector will be powered primarily by domestically produced biofuels, if we have the vision and the will to make that happen. Just as we sent a man to the moon, we can harness our technological skills and entrepreneurial spirit to end our dangerous reliance on foreign sources of oil." (Obama 2007).

4b. Visions and roadmaps in the European Union

In May 2003 the European Parliament and the Council enacted the Directive "on the promotion of the use of biofuels or other renewable fuels for transport" (Directive 2003/30/EC). This Directive obligated Member States to set national indicative targets for biofuels or other renewable fuels and to ensure that minimum proportions would be placed on their markets, with a reference value of 2 % in 2005 and 5.75 % in 2010 (art. 3.1 sub b). Greater use of biofuels for transport was justified as "a part of the package of measures needed to comply with the Kyoto Protocol" (recital 6), as a tool to increase the security of the energy supply and reduce the EU's dependence on imported energy (recital 7), and also as a way to create new opportunities for sustainable rural development (recital 15). The Directive also mentioned, but did not impose, the objective of 20 % substitution of conventional fuels by alternative fuels in the road transport sector by the year 2020 (recital 17). It must be emphasized that the Directive intended to promote not only the use of biofuels but also of "other renewable fuels" for transport. Recital 10 states: "Promoting the use of biofuels in transport constitutes a step towards a wider application of biomass which will enable biofuel to be more extensively developed in the future, *whilst not excluding other options and, in particular, the hydrogen option*" (our italics). However, this has proved to be a pious wish. As time went by, the hydrogen option increasingly disappeared from the picture and the focus would be directed at biofuels only.

In the European Union, just as in the United States, expert and stakeholder groups have been involved in formulating visions and roadmaps. Two important documents can be singled out. The most wide-ranging report is the so-called 'Cologne Paper' entitled *En Route to the Knowledge-Based Bio-Economy*, which was published in May 2007 under the German Presidency of the EU (EU 2007). The second report is entitled *Biofuels in the European Union: A Vision for 2030 and Beyond*. It is of somewhat more limited scope and was published in March 2006 by the Biofuels Research Advisory Council.

The first report, which resulted from six workshops held in Cologne in early 2007, covers the various fields that are considered to be part of the emergent 'knowledge-based bio-economy' (acronym: KBBE), including biomedicine and food and nutrition. It pleads for the appointment of a "KBBE-Coordinator" at the level of the European Commission, who would be in charge of "implementing KBBE (Research and Development, Healthcare, Agriculture, Environment, Energy, etc.)" and would be guided

by a "roadmap to KBBE" (EU 2007, 17). This plea reflects a rather technocratic view in which politics is replaced by implementation. The report *En Route to the Knowledge-Based Bio-Economy* also argues in favour of a strong IP policy, technology transfer and the "commercialisation of ideas", and advocates the inclusion of business-related subjects in the education and training of university scientists. The Cologne Paper further holds that an effective communication strategy must be directed at the general population to "raise awareness of the potential and necessity of biotechnology and the KBBE" (EU 2007, 13) – it would seem that this suggestion already crosses the thin line separating public education from propaganda.[9] The KBBE report expects, however, that the public acceptance of green biotechnology will increase in the next years as it is applied more and more to the generation of non-food products (including biofuels). "Future conflicts resulting from limited arable land for **food versus non-food** production", the report states, "need to be solved by innovation, e.g. by high tech crops, and by international regulation on an international level" (*ibid.*, 4). Thus technology and regulation are expected to solve the 'food-versus-fuel' dilemma. The report advocates a certification system for sustainable production to prevent the clearing of tropical rainforests for the sake of growing biofuel crops (*ibid.*, 17), but does not discuss the complications that may result from the cascading indirect effects of changing land use. Several other issues are also addressed in the KBBE report, but it would not be opportune to discuss them here.

The more narrowly focused report *Biofuels in the European Union* contains the following vision statement:

> "By 2030, the European Union covers as much as one fourth of its road transport fuel needs by clean and CO2-efficient biofuels. A substantial part is provided by a competitive European industry. This significantly decreases the EU fossil fuel import dependence. Biofuels are produced using sustainable and innovative technologies; these create opportunities for biomass providers, biofuel producers and the automotive industry" (BIOFRAC 2006, 3).

Thus, a very ambitious goal of a 25 % market share for biofuels in transport by the year 2030 has been formulated. It is also notable that the creation

[9] Natural scientists often hold somewhat naïve views on the role of science communication vis-à-vis the lay public. See, for example, Ank Jansen's interviews with Hahn, Dutang, Leschine, Parry, Swaminathan and Champey. For a more sophisticated view on science communication and public engagement, see Schuurbiers et al. (2007).

of economic opportunities figures quite prominently in the vision statement, just like in its American counterpart. Also remarkable is that the automotive industry has been given special mention. Elsewhere, the threefold aim is formulated thus:

> "The aim is to improve European domestic energy security, improve the overall CO_2 balance and sustain European competitiveness. The development of innovative biofuel technologies will help to reach these objectives." (ibid., 5).

Given its focus on "innovative" technologies, it is no wonder that the report devotes much space to the so-called *second-generation* biofuels. The claim is that this second generation, based on the effective processing of the lignocellulosic material of plants and trees (ibid., 11, Table 2.1), will overcome many of the drawbacks of existing (first-generation) biofuels and in particular mitigate or eliminate the possible competition between foods and fuels. Some critics therefore have suggested to skip the first generation entirely and to move directly to the second generation as soon as they are ready to be deployed. Others have responded to this criticism by emphasizing that the second generation will only arrive after the first generation has outlived its useful life: "Creating a market for first-generation biofuels paves the way for the second generation" (Marko Hekkert, letter to the editor, Volkskrant March 10, 2008). This logic may be nothing more than a rhetorical artifact of thinking in terms of 'generations'. The same point, now with regard to an even more advanced 'third generation', was made by Professor Emeritus Rob Kouffeld: "It is a fact of arithmetic that a third stage can only be reached after passing through the first and second generation, which we should therefore pursue as quickly as possible. We simply cannot afford to exclude the further development of biofuels" (NRC, 19/04/08, letter to the editor). This looks like the reverse from the well-known fallacy of the slippery slope in argumentation theory.[10] Generational thinking may thus lead to the failure

[10] It would not be warranted, however, to dismiss the argument as fallacious if the proponent specifies a plausible mechanism connecting the 'first' and 'second' generations of biofuels. In arguing the case for corn ethanol (the first-generation biofuel of choice in the USA), Vinod Khosla comes close to specifying the necessary connection: "… corn ethanol greatest value is as a 'stepping stone' and transition-point to cellulosic ethanol, butanol, and even more attractive cellulosic fuels. Corn ethanol offers the first step in the trajectory from 500 gallons per acre to 3,000 gallons of fuel per acre – it mitigates many of the early, technological and capital risks associated with cellulosic ethanol, and helps to develop the infrastructure necessary for cellulosic ethanol, as well as other biofuels. We need to hone our production technologies, get the flex-fuel automobiles […] in place and the infrastructure for pumping, storing, and

to develop a policy response to the manifest negative effects of first-generation biofuels and provide an excuse for inaction. As Doornbosch and Steenblik write in their critical OECD study:

> "The harmful consequences of many first-generation technologies have received widespread attention and are being acknowledged by an increasing number of experts (and a few countries). These concerns have not to date resulted in any effective policy response. One reason that first-generation biofuels continue to be promoted as serious solutions to the twin challenge of climate change and energy security is the notion that they will be soon supplanted by more advanced technologies now in development." (Doornbosch and Steenblik, 2007, 5).

The Biofuels Research Advisory Council also suggests in its report that we must first go through the first generation of biofuels before we can pass to the second generation. On p. 25 their report provides a linear *Technology Roadmap* (even in the form of a pointed arrow) with a clearly divided "likely timeline". In the short term (until 2010) existing technologies (for first-generation biofuels) are improved and R&D is done into second-generation biofuels and into the biorefinery concept; in the medium term (2010-2020) second-generation biofuels are deployed and the biorefinery concept is applied in demonstrations; in the long term (beyond 2020) large-scale production of second-generation biofuels takes place and integrated biorefinery complexes are deployed (Biofuels Research Advisory Council, 2006, 25). The report does not spell out any reasons why there should be a logical or physical or socio-economic necessity of passing through the first generation before embarking on the second generation. However, the report suggests *some* relationship between first and second generation:

> "The challenge is to increase substantially the production of biofuels by using innovative processes and technologies, which are both competitive and sustainable. To achieve this, it will be necessary, *while supporting the implementation of currently available biofuels*, to promote the transition towards second generation biofuels, which will be produced from a wider range of feedstock and which will help to reduce costs of "saved" CO_2" (Ibid., 13-14; our italics).

Perhaps the Council was not forced to think through the precise relation between first and generation because it assumed that the first generation could also be produced in a sustainable manner.

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transporting ethanol implemented – in effect priming the pump" (Khosla 2007a, 16). As a venture capitalist Khosla funds several next-generation biofuel projects, which lends some extra credibility to his words.

The report is also framed in another way by incorporating assumptions about future mobility in the EU and about the types of engines that will be used in road traffic. The projections used show a considerable growth of personal road traffic (increasing its share at the expense of rail) of trucks and of aviation (ibid., p. 12). These projections may be considered realistic, but treating them as simply "given" or as "data" still involves a normative or political decision. One could argue that really taking climate change and global justice seriously would rather call for a determined effort to bend down these growth rates. The same holds for the assumption that by the year 2030 the dominant engine design in road traffic will still be the internal combustion engine, whether in the Otto or Diesel variety (ibid., 22-23). This assumption may also be considered realistic, or conservative, but choosing these particular side constraints may also mean that the analysis is framed in favour of certain vested interests in the automobile and truck industry. (This also explains why the hydrogen option, still emphatically mentioned in recital 10 of the Biofuels Directive of 2003, has meanwhile disappeared from view.)

It is remarkable that the report itself warns for the dangers of premature lock-in:

> "To ensure competition in the delivery of competitive, low carbon and secure biofuels it is important not to lock into one product of technology today, but to create an environment in which such products and technologies can evolve" (ibid., 22).

Some American commentators hold that such a lock-in is happening in the United States, where the corn lobby attempts to "shackle the country to a single feedstock standard" (Herrera 2006, 760) and where corn stover will probably be the first cellulosic ethanol crop in the US, *not* because it is the ideal crop for that purpose (it has a rather negative environmental footprint), but because of "its massive acreage and to interface with existing ethanol producers" (Schubert 2006, 781) – the political leverage of the agribusiness company Archer Daniels Midland is thought to be an important factor in this choice.

5. Actors and their interests: the socio-political genesis of tunnel visions

While it may be too early for a definitive historical account of the formation of EU biofuels policy, the two critical reconstructions that are already available raise important questions. In June 2007, Corporate Europe Observatory (CEO) published a briefing paper entitled *The EU's agrofuel folly: policy capture by corporate interests* (CEO 2007a). Later that year, in

October 2007, the US-based Clean Air Task Force published a brochure under the title *Leaping Before They Looked* (Lewis 2007), in which some lessons were drawn from Europe's biofuels policy. The main thesis of the first publication is that EU biofuels policy has been captured by corporate interests through industry-dominated advisory bodies. The main thesis of the second publication is that European policy in the field of biofuels has failed to properly scrutinize the assumptions on which the policy aims and targets were based.

From the White Paper on renewable energy sources issued by the European Commission in 1997 to the passing of the Biofuels Directive in 2003, support for the promotion of biofuels in transportation steadily increased. During these years, little was done however to test the assumptions behind such a policy. The European Parliament qualified its support by declaring that more reliable methods for measuring CO_2 reductions had to be developed and that energy crops had to be grown in an ecologically sensible fashion, but it did not really insist on these conditions (Lewis 2007, 26). It was taken for granted that biofuels would help to reduce GHG emissions and thus to fulfil European obligations under the Kyoto Protocol and that they would also improve energy security. The US report also stresses that European efforts to promote biofuels have been largely driven by *farm policy* (*ibid.*, 7). They would, it was hoped, create new outlets for agriculture and help to alleviate the transition problems for the new EU member states in Central and Eastern Europe. What was not fully realized at the outset is that biofuels from the Tropics such as palm oil diesel or sugarcane ethanol have a clear competitive edge over any fuel products from crops grown in temperate zones as a consequence of more sunshine and lower labour costs. An unintended effect of the indicative market share targets announced in the Biofuels Directive has been a considerable expansion of oil palm plantations in Indonesia and Malaysia at the expense of tropical peatlands and rainforests, even though until now only an extremely tiny fraction of European demand for biofuels has been met directly from these sources (*ibid.*, 11). Due to indirect effects occurring through land use competition, the brochure commissioned by the US Clean Air Task Force believes that a certification system would not offer much hope for counteracting these negative consequences (*ibid.*, 14). The lesson this American brochure draws from the European experience with biofuels is that it is important to look before you leap. It approvingly cites Peder Jensen from the European Environment Agency who urges stakeholders and policymakers "to take a life cycle view" *prior* to making new biofuels commitments (*ibid.*, 24).

According to Corporate Europe Observatory (CEO), European biofuels policy has not even been driven by the fight against climate change; instead "it has sought to secure energy supply and serve the needs of large farmers and agribusiness, alongside the automotive, oil and biotech sectors, all with a direct interest in maintaining the existing status quo" (CEO 2007a). The influence of these sectors was clearly visible in the membership composition of the (now dissolved) *Biofuels Research Advisory Council* (BIOFRAC), a high-level experts group chaired by Volvo executive Anders Roj that was invited by the European Commission in early 2005 to "develop a foresight report – a vision for biofuels up to 2030 and beyond, to ensure a breakthrough of biofuels and increase their deployment in the EU". The result was the report *Biofuels in the European Union: A Vision for 2030 and Beyond*, appearing in March 2006, which has been discussed in the previous pages. The membership of BIOFRAC was distributed as follows: 4 automotive industry; 3 oil; 3 biofuel; 1 biotech (EuropaBio); 1 food industry, 1 forestry business; 1 energy business, 1 farmer; 8 from research centres and universities (often closely linked with the oil and biotech industry).

The prominent representation of the car industry on BIOFRAC is notable. According to CEO, European car manufacturers like Volvo and Volkswagen supported biofuels as a strategic answer to attempts by the European Commission to impose a mandatory efficiency standard for passenger cars in order to obtain lower CO_2 emissions. Thanks to heavy lobbying, the car industry succeeded in watering down the reduction target from the intended average of 120 gr CO_2 per km to 130 gr/km. The balance would be made up for with other GHG reduction measures, such as biofuels (CEO 2007a). Thus biofuels provided the European automotive industry with a welcome escape route for avoiding more stringent environmental standards on passenger cars.

Other industrial sectors have their own reasons for supporting increased deployment of biofuels. For the oil industry, for example, increased use of biofuels "will prolong current dependency of transport systems on liquid (petrol-like) fuels, which in turn allows oil companies to continue their profitable business while keeping a hand of control over the transition away from fossil fuels" (*ibid.*). The briefing paper points out that oil companies like Shell and BP are involved in several strategic alliances and joint ventures for developing new biofuels. It also notes that biofuels offers new economic and PR possibilities for the biotech industry, allowing it to make a green 'come back'.

Like BIOFRAC, the European Biofuels Technology Platform (EBTP) that was installed in June 2006 as a follow-up expert group to define EU's Strategic Research Agenda (SRA) on biofuels, is also heavily dominated by (the same) industry interests (Volvo's Anders Roj is vice-chair of the EBTP).

One need not share all of CEO's suspicions about the motives of industry to be concerned about the rather one-sided and unbalanced composition of such high-level advisory bodies as BIOFRAC and EBTP. They indeed represent a risk that EU policy-making may be captured by industrial interests and thus signify a democratic deficit. They also increase the likelihood that the Visions and Roadmaps formulated by such bodies will not explore the full range of possible futures but rather reflect the tunnel vision of a select group of stakeholders. The trouble is that such problems are not even recognized in official policy circles. Installing industry-dominated high-level expert groups is still standard practice and even deliberate policy in the present European Union. Responding to complaints from CEO, European Commissioner for research Janez Potocnik revealingly declared in June 2007:

> "European Technology Platforms have been conceived as a means to help realise the Lisbon Strategy. The platforms can play a key role in better incorporating industry's needs into EU research priorities by bringing together stakeholders, led by industry, to define a Strategic Research Agenda and to suggest possible directions for its implementation. This is the underlying rationale for the deliberate industrial focus of technology platforms, which was indeed, as you note correctly, reflected in BIOFRAC and is also manifest in the composition of the Biofuels Technology Platform" (quoted from Potocnik's letter, in CEO 2007b).

6. Entrepreneurs and their 'animal spirits'

Expectations about future technological developments are not only articulated within technology platforms and other semi-public forums that have been officially set up for 'visioning' and 'roadmapping'. Entrepreneurs and investors, including entrepreneurial researchers, who want to invest their money and skills or other resources in developing the new technologies, are also prone to base their decisions on expectations about the potential of these technologies. In this regard, they often tend to be overly optimistic. Indeed, without a large dose of optimism they might not be willing to invest their funds, reputation or talents at all. In this section, we will briefly look at two American 'entrepreneurs' – a venture capitalist (Vinod Khosla) and a researcher (J. Craig Venter) – and their visions of the

future to complement our analysis of the semi-official visions and roadmaps on biofuels. If anything, their expectations are even more sanguine than those formulated by semi-official bodies. However, as long as they are held by private actors and do not directly determine public policy, such overly optimistic expectations do not raise the same serious issues.

The economist John Maynard Keynes once famously remarked that "a large proportion of our positive activities depend on spontaneous optimism rather than on mathematical expectation", and he continued:

> "Most, probably, of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as a result of animal spirits – of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities" (Keynes 1973 [1936], 161).

In this sense, optimistic expectations can be seen as feeding the 'animal spirits' investors and entrepreneurs need in order to be willing to undertake risky projects in a capitalist economy. This point will be illustrated with the examples of two American 'entrepreneurs'.

Vinod Khosla is an American venture capitalist of Indian descent who has invested a lot of money in various advanced projects to develop next-generation biofuels. He is an enthusiastic propagandist who easily waxes eloquent about the immense opportunities opened up by new developments in the life sciences. What is more, he also puts his money where his mouth is – or should we perhaps say that his mouth is where he puts his money? Against sceptics who question the near- to medium-term prospects of cellulosic ethanol, he cites the example of the several ventures that he co-funded:

> "Plants and demonstration plants are not pipedreams – they are being built right now by at least a half dozen separate companies. Are they all wrong? We have invested more than our word in these beliefs – we've invested money, which is the only objective test of belief about readiness" (Khosla 2007a, 18-19).

Measured by this test, Khosla's claims should indeed be taken seriously.

Reading Khosla's many articles displayed on his website, or listening to his public lectures that are available on YouTube, it is difficult not to become infected with his contagious enthusiasm. As a forward-looking venture capitalist he is motivated by strong animal spirits. America, he holds,

should prepare for a "war on oil" to find replacements for petrol, diesel, aviation fuel and other products made from oil. Khosla accuses the biofuel sceptics (denounced as 'naysayers') of following the traditional "what is" approach instead of the dynamic "what can be" approach. He holds that the advances of science and technology are turning many impossibilities of yesterday into the new possibilities of tomorrow. The new opportunities can be grasped by those who have liberated themselves from the rigid mindsets of vested interests and established industries (in this case the petroleum-based industries):

> "Many impossible things are becoming possible. We have seen many debates on the internet on why we don't have enough land, why the energy balance won't work, why we cannot scale fast enough, and on and on and on. They are generally right if one takes a traditional approach, but these new ideas and approaches [developed by the bright people working in the renewables industry] are attempting to bypass these limitations, find clever workarounds or alternative paths. Some will work and some will fail, but *we suspect the world will be well on its way to solving its oil dependency crisis within a decade if not within five years*" (Khosla 2007b, 3-4; our italics).

Somewhat ironically, given his iconoclasm with respect to established industries like the oil business, for Khosla the economic attraction of biofuels is precisely that they leave western automotive lifestyles largely unchallenged. Only a very small technical adaptation is required: "Cars can be made as flex fuel vehicles (FFV's) capable of running on either gasoline or ethanol for a marginal cost of only $35 per car!" (Khosla 2007b, 4). He even contemplates the possibility of having negative carbon emission per mile driven: "Imagine a scenario where driving more could actually lead to lower levels of carbon emissions!" (Khosla 2007a, 17). That would indeed be great: the more miles you drive in your car, the better for the environment. Thus the capitalist gales of creative destruction may ultimately dislodge the oil industry (or so Khosla hopes), but they will apparently leave our mobile lifestyle untouched. Here we see the narrative element of the *technical fix* that Eames et al. (2006) have identified in various forecasts and scenarios:

> "[Biofuels are] seen as a technical fix, allowing us to retain our current lifestyles regardless of the all-too obvious problems of oil scarcity, climate change and air pollution. Scenarios of 'technological optimism' frequently include [biofuels] as the saviour of modern society. Policy briefs from thinktanks describe [biofuels] as the pragmatic solution to a range of environmental and security problems, obviating the need for painful (and politically difficult) social change" (Eames et al. 2006, 364; in the quoted passage we have substituted 'biofuels' for 'hydrogen').

We have seen that CEO (Corporate Europe Observatory) in its critical comments about the European biofuels roadmapping exercise also alluded to the technical fix argument, but added a negative twist to it. In their view, biofuels would "prolong" current dependency of transport systems on liquid fuels.

Khosla has a strong faith in the ability of the capitalist system to harness new ideas:

> "The power of ideas fuelled by entrepreneurial energy is the key to displacing oil. This is the innovation ecosystem at work and it thrives on big problems and big opportunities" (Khosla 2007b, 24-25).

Indeed, Khosla is a self-confessed technology optimist for whom every problem constitutes an opportunity:

> "Our approach is one that says every major problem is a major opportunity and often (but not always) it is just a question of focusing attention and resources on a difficult technical problem and it will be solved. We are technology optimists. No problem, no solution, no opportunity. A big problem to us means a big opportunity. Most of the problems in energy technology seem eminently solvable and suffer primarily from a lack of focus from the best minds in the country on it" (*Ibid.*, 24).

A similar attitude is adopted by the entrepreneurial researcher J. Craig Venter, who earlier contributed to the sequencing of the humane genome but is now active in synthetic biology. He wants to signal to the general public that his enterprises (consisting not only of the nonprofit *J. Craig Venter Institute* but also of the private company *Synthetic Genomics, Inc.*; patent rights will all be assigned to the latter) intend to play a key role in solving the urgent problems of energy supply and climate change. In his Richard Dimbleby Lecture delivered on 4 December 2007 on BBC One, he went so far as to suggest that synthetic biology and metabolic engineering may save the world and effectively constitute humanity's last chance for survival.[11] Venter also denounces the pusillanimity and timidity of the biofuel sceptics and invokes a generalized version of Moore's Law, which

[11] The catch is that Venter's company Synthetic Genomics Inc. is aggressively patenting the synthetic organisms that are to produce the new biofuels and all the associated techniques and products, so that the inventions that theoretically could save the world (according to Venter's testimony) when used by everybody, become locked up in patents that make them inaccessible to any but the most wealthy licensees or buyers.

claims that science and technology will grow exponentially, to silence their criticisms:

> "The pedantic argument concerning future inventions is how can we count on new technologies that don't yet exist? [*Why 'pedantic'? To us this would seem to be a good point!*] Some can look at the past and see no change for the future, while others will extrapolate forward in a linear manner. However, there are some fields where predicting and counting on exponential change has become reasonable and reliable. For example, Gordon Moore, a founder of the computer chip giant Intel, predicted that the density of transistors on integrated circuits would double every 2 years, a prediction that became referred to as Moore's Law. […] If such predictions of exponential change have come true for the electronics industry [...], then isn't it possible the same could hold true for changing education, medicine, replacing the petrochemical industry, and saving the environment?" (Venter 2007).

Interestingly, since the debate between Malthus and Condorcet at the end of the 18th century, faith in the allegedly 'exponential' growth of science and technology has often been a key argument to play down the predicted dire effects of population growth.[12] It now recurs in the guise of a generalized version of Moore's Law, which has been popularized in the US by Ray Kurzweil and other gurus of the coming nanotech revolution. This generalized version is invoked to boost our confidence in the new technologies that are expected to effectuate the transition towards a carbon-neutral world. While Venter provides some examples derived from genomics where the pattern of exponential change seems indeed to have

[12] A characteristic example is the argument of the young Frederick Engels against the Malthusian theory of overpopulation: "Malthus establishes a formula on which he bases his entire system: population is said to increase in a geometrical progression -- 1+2+4+8+16+32, etc.; the productive power of the land in an arithmetical progression -- 1+2+3+4+5+6. The difference is obvious, is terrifying; but is it correct? Where has it been proved that the productivity of the land increases in an arithmetical progression? The extent of land is limited. All right! The labourpower to be employed on this land surface increases with population. Even if we assume that the increase in yield due to increase in labour does not always rise in proportion to the labour, there still remains a third element which, admittedly, never means anything to the economist -- science -- whose progress is as unlimited and at least as rapid as that of population. What progress does the agriculture of this century owe to chemistry alone -- indeed, to two men alone, Sir Humphry Davy and Justus Liebig! But science increases at least as much as population. The latter increases in proportion to the size of the previous generation, science advances in proportion to the knowledge bequeathed to it by the previous generation, and thus under the most ordinary conditions also in a geometrical progression [read: exponentially]. And what is impossible to science?" (Engels 1974 [1844], p. 175).

occurred, he extrapolates Moore's Law to so many other fields (in fact, its scope of application is not clearly specified) as to turn it effectively into an article of faith.

7. Hype, hope and sound scepticism

It is not difficult to imagine that the contagious enthusiasms of Khosla and Venter, especially when sustained by strong entrepreneurial animal spirits, can easily spill over into a hype affecting and seizing many others. Then the danger may arise that increasing pressure will be exerted to take such expectations as the basis for public policy. We naturally grant Khosla and Venter the right to have their own private hopes and to act on their expectations of unbridled technological optimism. Faith, hope and charity remain core virtues. It is indeed desirable in a capitalist market economy that entrepreneurs are willing to invest their skills and money in the realization of their technological dreams. However, it would be problematic if their private dreams directly determined the public agenda. The government is not, or should not be, in the business of "picking winners" among the set of candidate technologies for the future. Premature 'lock-in' must be avoided. It is therefore regrettable that a venture capitalist like Khosla makes his willingness to invest in the development of next-generation biofuels conditional upon the prior creation of an infrastructure (pipelines, fuel stations, flex-fuel vehicles) for first-generation biofuels like corn ethanol, so that the eventual arrival of more advanced biofuels will find a ready and well-prepared environment. First-generation biofuels are thus seen as a 'stepping stone' or 'gateway' for next-generation biofuels. Given the doubtful environmental and energetic merits of the first generation and the still uncertain prospects and performance of later generations, public policy may thus be held hostage to the technological optimism of private entrepreneurs.

There is a real danger that an emerging hype will engulf (almost) everyone, including the government. Presently dominant forms of forecasting and scenario analysis like 'visioning' and 'roadmapping' often jump on the bandwagon of existing hypes and do not provide a hospitable setting for the critical testing of assumptions. The primary function of Technology Platforms and similar forums engaged in visioning and roadmapping is to get the participating stakeholders ligned up in the same formation and to build consensus and commitments for the realization of particular futures. However, in dealing with major problems like global change, the first priority may not be to build a base of social support for a particular policy. Reflecting on the dismal experience of educational reforms in the

Netherlands, political philosopher Margo Trappenburg hammers home the following message: "One should not try to create a base for social support, one should organize dissidence" (Trappenburg 2008).[13] In the case of reform proposals for the public sector, it is not easy, according to Trappenburg, for parliamentarians to penetrate the weaknesses of submitted reform proposals and to critically scrutinize their underlying assumptions, because those plans are usually dressed up in an endless series of 'cheer-words' (*hoerawoorden*). Hence the urgent need in this area to organize dissidence and counter opinion ('tegenspraak').[14] Similar 'cheer-words' can be found in the area of biofuels: renewable, climate friendly, carbon neutral, sustainability, eco-efficiency, the 'knowledge-based bio-economy', and the prefixes 'bio' and 'eco' and the adjective 'green' in many word combinations – all seemingly referring to inherently good things. Who could possibly be against or even doubtful? It would thus seem that in this area too there is an urgent need to organize dissidence. This suggestion also entails that in the process of policy preparation and policymaking the functions of exploring possible futures and of creating social consensus and commitments should be more clearly separated.

Is it possible to resist hypes? Can we create some built-in immunity against hypes in public policy? For a constructivist like Nik Brown there is no easy exit from the 'hope versus hype' dilemma, because it is an illusion to think that we can somehow factor out the hype: "[W]e cannot place ourselves outside the world of expectations as if we were objectively disinterested observers … [I]t would be impossible to fully disentangle present hype from future reality" (Brown 2003, 17). Even if we cannot, on grounds of principle, rule out hype, however, "a reflexive engagement with expectations" can "become more sensitive to the many hidden futures that hype so often silences" (ibid., 18). Brown therefore advocates the "opening

[13] In Dutch: "Er moet geen draagvlak worden gezocht, er moet tegenspraak worden georganiseerd".

[14] "With proposals for the renewal or improvement of the public sector, critical dissidence does not arise automatically, because those proposals are often dressed up in an endless series of hurrah-words: child-centred education, customized care, demand-led steering, integral approach, coherent supply, context-rich learning process, competence-oriented learning, quality monitoring, freedom of choice, transparency, and what not. With such plans it is important to solicit counter opinion much more explicitly. We need critical advisory bodies with members who do not ask themselves first and foremost 'how their recommendations will land among policymakers'. We need commentators with a reputation of being skeptical critics. We need professionals with decades of experience who in the past have seen hypes come and go and who are able to judge plans also from this perspective – and who also dare to say no." (Trappenburg 2008).

up [of] expectations to greater pluralizing pressures", and warns that this "will not make biotechnology's futures less contested" (ibid., 18). He is not very specific, however, about the way this "opening up" must be organized. Simply broadening the social base of the visioning and roadmapping forums by including presently excluded groups may just lead to very general, broadly interpretable and noncommittal formulations that only suggest rather than truly express a shared vision (Eames et al. 2006, 367).

There is at least one example of apparently successful resistance vis-à-vis technological hypes, to wit, the European response to the American NBIC (nano-bio-info-cogno) initiative (Roco and Bainbridge 2002), as formulated by the High Level Expert Group in the so-called CTEKS report (HLEG 2004; for a brief overview of the characteristic differences between the US and European approaches, see Coenen et al. 2004). While the US report on converging NBIC technologies, sponsored by the National Science Foundation and the Department of Commerce, exhibits a futuristic, technological-determinist and almost utopian view on the potential of these 'converging technologies' and holds out the promise of enhanced performance in all areas of human life, the European CTEKS report takes a much more sceptical attitude towards the expected outcomes of technological advance and favours innovation geared to recognized social and cultural needs of present society over high-tech initiatives aimed at ultimately realizing individual human enhancement. It is probably not a coincidence that the *rapporteur* of the CTEKS report, the German philosopher of science Alfred Nordmann, has written extensively about various possibilities for strengthening our intellectual ability to resist the overwhelming power of technoscientific hypes (e.g. Nordmann 2007). One example is his criticism of the use of Moore's Law to validate improbable futures, but there are many more.[15] Nordmann's inventory of the various sleights of hand, fallacies and modes of inference that are commonly used to rhetorically transform remote possibilities into actual and inevitable developments may provide a welcome cognitive antidote.

[15] "Indeed, the most suggestive 'argument' for a hypothetical future that is upon us already comes from a large family of logarithmic plots that extrapolate an accelerating speed of technical development from the past via the present into the future. If past and present trends continue, so the argument goes, even seemingly remote technical capabilities will be upon us before we know it. These graphs not only extrapolate from the more or less recent past into the future but are themselves the result of an extrapolation from the computer industry's 'Moore's Law' to all technology. Though they have no standing among academic historians of technology, these graphs nevertheless enjoy credibility and considerable popularity… [Moore's Law] serves to establish the if-and-then when it is taken as a universal law of nature and history." (Nordmann 2007).

The intellectual tools for resisting hypes are already there, the question is rather whether we are ready and able to use them. This may also depend on the prevailing cultural climate and the extent to which the socio-political regime allows for or even encourages the development and expression of dissidence and counter opinion.

3. Saline agriculture

This case study describes three ways in which issues of salinity can be, and are, framed as issues for agricultural innovation. They are very different. The first frame is Dutch, and connected with a broad national effort to reframe perspectives on water management. It aims to find new solutions for the diminishing economic perspectives for saline soils in the Netherlands. The second framing of saline agriculture centers on the sea. In one of its forms it centres on the promises of algae, which are (in turn, in one of their forms) potentially important crops in the development of "marine agriculture" or "sea culture". The frame is unstable: it evolves quickly in various directions. The third approach frames saline agriculture as a world wide search for "climate-ready" genes for new crops and is immediately associated with controversies on transgenic crops. It promises new biotechnological solutions for the increase of saline soils and other consequences of climate stress.

This case study, too, will show that a fixation on new technology creates a succession of hypes. Besides, it will become evident that low tech innovation agendas are underappreciated and suffer from neglect. A more robust societal innovation agenda is needed to counter the random drift of social expectations that results from this imbalance. Given this need, the present shift in GM debates towards issues of power and intellectual property is a hopeful one, as it embeds technology within a societal agenda.

Section 1 describes the three ways to frame salinity. Section 2 concentrates on further developments and characteristics of these frames. Section 3 draws conclusions.

1. Three ways to frame saline agriculture as an innovation issue

1a. Saline soils: an opportunity?

Around the year 2000, a major shift took place in Dutch water policy. Given the trends of rising sea levels, sinking ground levels and new extremes in river-levels, new approaches were needed. The proposed change had the characteristics of a major transition: a dramatic change was to take place from keeping the water out as much as possible to making room for it, and fighting it as our worst enemy to cherishing it as a friend.

One element of the transition concerned the increasing salinization of Dutch soils. In the old situation, salinization was seen as a major problem for agriculture. One of the goals and priorities of Dutch water policy was to supply agriculture with all the fresh water it needed. According to the new view, however, The Netherlands would do well to see the salinization of soils not as a problem but as a challenge for innovation: the development of "saline agriculture". A study of the "Innovatienetwerk", *Saline perspectives* (Fiselier 2003) embodies this need for a change of perspective. It sketches the problem of the increasingly saline Dutch soils and argues that the possibilities to fight this problem are diminishing. Therefore, we need a new perspective on agriculture, a perspective that puts water instead of land at a central place. Brackish and salt as well as fresh water should have a place in this new agricultural paradigm.

The report gives an overview of the potential use of brackish and salt water for agricultural purposes, emphasizing that with a creative attitude, problems can be turned into chances, since many potential solutions are near at hand. Brackish water, for example, is eminently suitable for growing traditional salt-tolerant crops such as barley as well as new (new, that is, from a commercial perspective) ones such as protein-rich *Lemna* (eendenkroos). Salt water offers opportunities for commercial production of many traditional food plants, such as *Salicornia* (zeekraal). Such estuarine production is put in a perspective that emphasizes the rediscovery of salt-tolerant crops alongside the (multifunctional) use of such areas for recreational purposes and as natural areas. The report stresses that the change amounts to a "system innovation" (Fiselier 2003, p.37) and should be based on a new consensus. This in turn requires effort and cooperation of many parties: entrepreneurs, researchers, policy makers and other societal groups.

In short, the innovation network tries to tackle the problem of salinizing soils by promoting a fresh and innovative perspective on salinity which makes the realities of water central in agricultural thought. Within such a perspective, solutions are near at hand, in large part in the form of existing salt-tolerant plants.

1b. Algae: farming at sea?

In 1998, the US Department of Energy published a report in which it looked back on 20 years of research into algae as a source of biodiesel. The message of the report is that great progress had been made in the biotechnological handling of algae, and biological perspectives were very

promising. Costs, however, were seen as an unsurmountable obstacle: "Even with aggressive assumptions about biological productivity, we project costs for biodiesel [from algae] which are two times higher than current petroleum fuel costs" (Sheehan et al, 1998).
Likewise, in a 1998 essay for the Dutch NRLO it is stated that direct production of fuel from marine algae is possible in principle, but that costs are the problem: algae cannot compete with fossil energy. Nevertheless, the author looks ahead and continues: "Of course, this is only a matter of time, time that policy preparation and research should not waste. Biotechnological research is especially necessary, in order to get a grip on production." (Van Zon, 1998, p.69)

However insightful this remark may seem today, at the time an experimental algae factory was not seen as an urgent necessity. In 2003, a Dutch report of the Innovatienetwerk on Marine biotechnology (Schmalz en De Kempenaer, 2003) comes to the conclusion that an experimental algae factory could be an important contribution to innovative potential. Yet, the need for such a factory in the short term was not widely felt, the report stated, and the idea would have to wait. It should be added that in this report algae were not primarily seen as a source for fuel, but mainly as a source for food and other useful resources (agar, etc). Until very recently, this was the main perspective on algae in most contexts and reports. But whether algae were regarded as a source for food, non-food products, or fuel, the conclusion was almost invariably that they were extremely promising from biological and technological points of view, but that market potential was limited or lacking (e.g. Lindeboom and Fonds, 1998, Sheehan et al, 1998, Van Oosten en De Wilt, 2000, Schmalz en De Kempenaer, 2003, Langeveld et al, 2005). Only for high-grade products such as food or cosmetics, opportunities were sometimes seen. In their study on new forms of agriculture, Langeveld et al (2005, p. 34) conclude: "Production of algae for fuel purposes alone is not feasible. Algae do constitute promising production systems for high grade resources for food, aquaculture, cosmetics or fine chemicals, and there is enough know how in the Netherlands to make this economically successful."

The low profile of algae changed when oil prices began to rise and the search for biofuel took more serious forms. Algae were widely and rapidly discovered as a rich source of oil (biodiesel) that not only might well compete with fossil fuel but is also far more climate friendly. With the demise of first generation biofuels, the (third generation) hopes surrounding algae rose. Biotechnological awards have been given to alga proposals, and websites, media attention and commercial initiatives

abound. Fresh water algae as well as marine algae are useful in principle, and it remains to be seen which types of algae will turn out to be most productive and useful in practice. On the one hand, some believe that marine conditions are most promising. There are now proposals for big "open sea farms" comprising thousands of hectares of seaweeds (macro-algae) in combination with enormous windmill parks above sea level and fishing hatcheries below the weeds. On the other hand, closed fresh water production systems of micro-algae will be more practical to manage and control.

In short, the biological potential of algae has long been recognized, but their economic potential suddenly caught attention in the context of the search for biofuels. How and for what purposes and which types of algae will really turn out to be commercially useful is still very much uncertain. The algae frame is not at all stable; the potentialities of algae as well as those of the sea are explored in many directions. For example, marine algae draw attention more generally to the vast production capacity of the sea ("zeebouw"). More generally, in the search for new resources emphasis easily shifts, from marine algae to fresh water algae and/or back, from marine algae to other forms of sea-culture, from biofuel to other algae products. But what is firmly *out* of sight in this algae-centered framing is the problem of saline *soils*.

1c. Climate-ready genes: GM and corporate power

The world needs ever more food, and as the climate is changing, ever more crops will have to be grown in environments that are not ideally suitable. Growing plants will increasingly have to deal with various forms of stress: drought, salinity, heat, cold, nutrient deficiency, UV irradiation, etcetera. This is the background of a search (through genetic engineering as well as classical breeding) for genes that can make plants more resistant to various stressful conditions. This search started some decades ago on a modest scale but has intensified during the last few years. For example, the network of 15 public research institutes that operate under the umbrella of the CGIAR (Consultative Group on International Agricultural Research) announced an intensification of their efforts on "climate ready" crops in 2006. So far they have used mostly, but not exclusively, conventional breeding.

Very recently, the Canadian ETC group (a watchdog that addresses socioeconomic and ecological issues surrounding new technologies) has called attention to the intensification of the search for stress-tolerant

crops, warning that big corporations are quickly appropriating the field through gene patents that make enormously broad claims (covering many species under the same patent file. "Gene giants grab climate genes", is the title under which the ETC announces its report on the subject). The report itself, titled "Patenting the 'Climate Genes' and Capturing the Climate Agenda" (ETC, 2008), documents that the world's largest seed and agrochemical corporations are "stockpiling hundreds of monopoly patents" on genes in plants that can make them withstand stresses such as drought, heat, cold, flood, salinity etcetera. Three companies (BASF, Syngenta and Monsanto) are responsible for two thirds of the patent filings in this area. BASF and Monsanto have formed partnerships with CIMMYT (International Maize and Wheat Improvement Center, a CGIAR institute) and the Bill and Melinda Gates Foundation. This trilateral partnership aims to make this technology available for poor areas such as sub-Saharan Africa, where (as a first application) transgenic solutions to drought stress in maize could be introduced.

According to the companies, gene-altered plants will be crucial to solving world hunger and will never be developed without patent protection. According to the ETC group, however, this is a PR offensive in which the corporations push genetically engineered crops as a silver bullet to climate change and re-brand themselves as climate saviors, while the biggest winners are BASF and Monsanto themselves "who can now point to their philanthropic efforts to give royalty-free drought-tolerant genes to the neediest farmers in Africa-with full endorsement from public plant breeding institutes." ETC opposes this strategy. Instead, it advocates a farmer-based approach that emphasizes the (local) maintenance of heterogeneous varieties and the investigation of under-utilized species as a resource for the selection and breeding of useful traits. Farmer-to-farmer alliances are also part of this strategy, as farmers typically draw on breeding materials from their own communities. ETC here sides with a recent report of the IAASTD (International Assessment of Agricultural Science and Technology for Development) that also stressed the strengthening of farmer's strategies. [16] In conclusion, ETC writes that poor farming communities risk being stampeded by a corporate climate agenda. Governments must respond urgently and suspend all patents on climate related genes and traits, while strengthening farmer-based breeding.

[16] GM-controversy surrounds that report as well; there have been complaints that the assessment was "hijacked" by participants who oppose genetically modified crops.

In this framing, salinity is one of the agricultural problems that result from, or are aggravated by, climate change. The problems are to be countered by breeding new genetic varieties that can cope with the changed environments. Within this field, a GM approach is now catching attention, which in turn implies that GM controversy immediately dominates the debate. Opposition to GM is undergoing a shift away from opposition to the technology itself, and now increasingly focuses on corporate power and intellectual property claims associated with the technology. In an article in the Washington Post on the ETC report (Weiss, 2008), Richard Jefferson, founder of Cambia (an organization that looks for open source alternatives to patents), finds ETC extreme in its anti-corporate views but agrees that the power of the big corporations is far too great. "I don't mind Monsanto developing these tools", he is quoted as saying; "I mind that we don't have an economic ecology that lets other companies compete with them."

2. Frame Dynamics

The three frames presented here represent different ways in which salinity can become and has become an issue on the societal agenda. The sections below re-address the frames, now with a focus on how each frame has been developing, and on (some of) the mechanisms and characteristics that influence these developments. The analysis will concentrate on elements of the frames that are especially relevant in the context of this study.

2a. Saline soils: Tradition-based innovation?

The first frame addresses the problem of increasingly saline soils and emphasizes that the problem can also be seen as an opportunity if it is seen in a new perspective, a perspective which gives pride of place to water, including brackish and salt water.

So far, the approach has not been very successful. The Innovation Network, in a series of report of 2007, (Guldemond et al, 2007, De Kempenaer & Brandenburg, 2007, Innovatienetwerk, 2007) has taken a new look at the increasingly saline Dutch soils. The urgency and growing extent of the problem are repeated and it is pointed out again that many plants that grow well in brackish water are readily available, many of them traditional, and sometimes forgotten or half-forgotten. Combinations with tourism and nature development are also stressed again, and new concrete ideas are mentioned (such as salt villages and "Ziltgoederen").Yet, the innovation network notices, so far saline agriculture is not coming off the ground at all. It seems to be caught in a vicious circle of small demand and small

production. There are few initiatives, the agricultural sector hardly shows an active interest nor are there other signs of interest or a sense of felt urgency from the business sector. Very little R&D work is done in this area, and governmental as well as agricultural institutions remain largely focused on a fresh water-dependent agriculture (Innovatienetwerk, 2007).

The reports deplore this lack of activity, for if nobody acts, fairly substantial saline areas will become useless for agriculture and landscape development. Vision, creativity guts, and a big change of attitude will be needed at many places and with many actors. The Network recommends starting a business platform for saline agriculture in order to break the vicious circle, and announces that it will remain active in concept innovation for the problem of increasingly saline polders, as they get very little attention while they require ever more urgent transition efforts.

The problem is not that things go wrong, but rather that things do not seem to happen at all. The reasons for this impasse are no doubt complex and heterogeneous. In the context of this study, a conspicuous characteristic of this frame is the absence of (bio-)technology. The Network stresses an innovative attitude, but not innovative technology. Although development and breeding of new crops are mentioned, the emphasis is overwhelmingly on the excellent opportunities offered by existing salt-tolerant plants. The predominant message is that innovative agricultural perspectives and business concepts are needed, but that the plants only need to be rediscovered and re-valued.

There are more initiatives that focus on the revival and preservation of traditional plant varieties, and a consideration of parallels may be revealing. A recent documentary on Dutch television, called "Eternal Mash" (Holland Doc: Eeuwige Moes), focused on an initiative called the "Oerakker", and the people associated with it. On this field, near Veenhuizen in Drente, Ruurd Walrecht for some years made great efforts to cultivate and preserve traditional and forgotten varieties of vegetables. He collected traditional plants and seeds from all over the country, loving and cherishing their diversity and deploring the impoverishment of present day varieties and tastes. The documentary could not show the daily work on the Oerakker, however, as it had suddenly come to an end a little earlier. Having become demoralized after years of problems, opposition and lack of financial support, Walrecht abruptly ended all his activities in 2006 and left the country. Three of his former collaborators look back on his work and mourn his departure. The documentary shows three men, two of whom live self-supporting lives in close contact with nature, while the third now

devotes his life to religion. They are not men in close contact with new technological developments, on the contrary; the idea inevitably arises that the Oerakker has been the work of rather unusual people who are out of tune with present day technological and international development. Their lives and work are also out of tune, for example, with the developments of European standards for vegetables, according to which cucumbers should always be straight and green.

Yet, the documentary continues by showing that the seeds Walrecht left behind are now collected, frozen and stored by scientists of Wageningen University. The scientists explain that they consider it very important to preserve the genetic diversity represented by those seeds. The University also makes such material available to researchers from outside the university, and one of the Wageningen scientists, professor Edith Lammerts van Bueren, comments that it is a sour thought that biotechnology firms might end up using the Oerakker seeds for GM purposes.

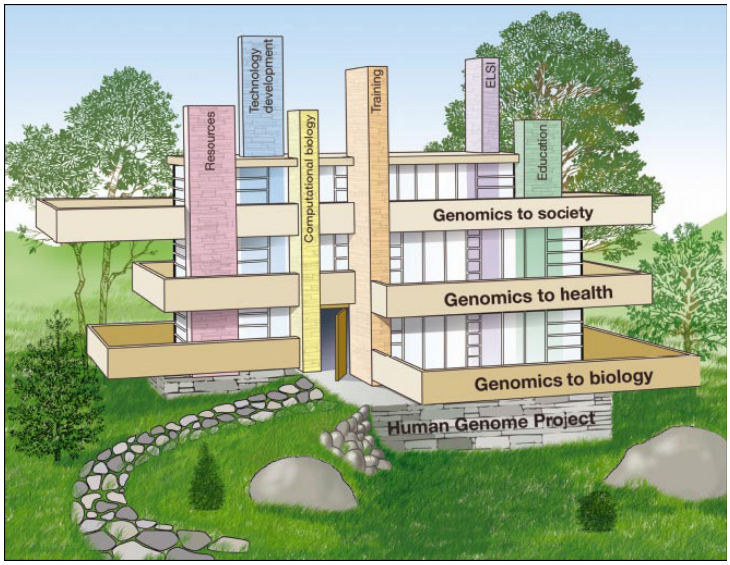
The Oerakker-case, extreme though it may be in its stark contrasts, suggests that an active interest in the cultivation of traditional plant varieties—as opposed to the preservation of biodiversity in genetic storage banks—is a countercultural and marginal activity in our society. Only marginal people, who do not succeed in convincing subsidizers of the importance of their work, really seem to care about these vegetables… Again: as opposed to their genes, which are important for scientific and potentially also biotechnological reasons.

The documentary sheds a specific light on the faltering attempts to accomplish an innovative approach to saline soils with the help of traditional plant varieties, strengthening the suggestion that approaches that build on local and traditional (low tech) knowledge are out of tune with today's dominant innovation climate, in which the settings are global, and social hopes and attention are focused on new technologies, controversial though they may be at the same time. The dominance of globalisation and new technology does clearly not imply that locality and tradition are no longer present. But tradition and locality has become associated with counter- or subcultural values, which are not at the innovation frontier. They are more easily associated with tradition and conservation than with innovation.

2b. Algae: A technology-driven agenda

In the "Algae for Biofuels" frame, marine algae supply one potential route to new resources, be it for biofuel or food or other useful purposes. However, in a new domain such as this, hopes and hypes may appear and disappear rapidly, and may diverge in very different directions. For example, the idea to boost the sea as a source for carbon dioxide binding by fertilizing it with iron to stimulate phytoplankton growth (including algae) has come up, blossomed for a few months and (for the time being) gone under again, because of the uncertain ecological impact. The idea of using the sea in new ways is also developed in directions that have nothing to do with the salinity of the sea. For example, there are various plans for windmill parks in the open sea.

Technology is a great source of innovation but also tends to come with unforeseen and/or problematic social implications, which is why there are now ELSI- and ELSA-programs which address the Ethical, Legal and Social Implications (or Aspects, respectively) of new technologies, such as genomics and nanotechnology. As the names indicate, these programs are studying the (ELS) *Implications* or *Aspects* of new technologies. ELSI in particular defines a technology-driven social agenda that takes its point of departure in new scientific and technological developments. ELSA is broader in principle, but in practice also tends to be very technology centred. The (implicit or explicit) relation between science and society in ELSI research is one in which society builds on the results of science. The following picture of ELSI-genomics research, from Collins et al (2003) visualizes this metaphor of science as a foundation on which society builds.



The model fits in well with competitive interests. In a competitive and globalizing world, you need to be at the frontiers of innovation, and the temptation to quickly follow the lead of new technologies is great. A basic fear is to "miss the boat". In line with the model, new technology is an important subject of commercial as well social and moral attention. For moral agendas, this implies particular biases.

First, while new technology is just one potential source of departure of moral analysis, it receives abundant treatment. The prominent place of technology may lead, for instance, to intensive discussion on implausible transhumanist future scenarios, while urgent (but familiar) problems that have no connection with new technology, such as ordinary health problems in many countries, suffer from moral neglect (Nordmann, 2007a, Van der Weele, in press).

Second, social agendas that are derivative of technological developments are subject to developments on technological frontiers. For example, when the promise of some technology to solve an urgent social problem changes from bright to dim, the social focus associated with that technology changes accordingly: it may suddenly turn to very different social applications. To the extent that social agendas are dependent on technology development, they are thus sensitive to the vicissitudes of the new technology, and may be drifting with these vicissitudes more or less randomly, from a social point of view.

The algae-framing of salinity certainly shows signs of such random drift. To begin with, as mentioned above, developments of the idea of sea-culture may take forms other than the cultivation of algae, for example the exploitation of windmills. Also, the cultivation of fresh water algae may turn out to be more practical and cost effective than that of marine algae. At present, most attention is certainly focused on fresh water algae. For example, when KLM announced at the end of May 2008 that it wants to fly on kerosene from algae within a few years, the contacts it had were with a firm that grows fresh water algae in closed tanks.

More generally, the recent developments of the algae-adventure illustrate that the future of algae cultivation is far from certain. In an account of a recent scientific-commercial algae conference, Karel Knip (2008) writes that while the conference began with the call not to miss the boat, disenchantment soon struck: "Before 11, one of the speakers used the words 'hype' and 'absurd'. Interest for algae was a hype and what KLM wants was absurd." This speaker (Jan de Wilt of the Innovation Network) said that algae may be promising, but not for the purpose of biofuels, on which so much hopes has been concentrating lately, because breeding them will always take more energy than it delivers. Biofuels may be produced, but this can only be attractive when algae are grown on waste, for example as a by-product of half-closed cycles where they can contribute to a cradle-to-cradle approach. The real promise of algae is in different fields: high-grade applications such as food and nutraceuticals. The surprise of the conference, according to Knip, was that experienced people already know that growing algae with the primary intention of making biofuel is bound to fail. As we saw above, this was a conclusion Langeveld et al (2005) indeed drew some years ago.

Making algae commercially useful is an endeavour that is full of promise, and for fear to miss the boat many groups in society are following closely. Yet the applications that will turn out to be viable are still very uncertain, and thus an algae frame is not a good focus, at least not in an exclusive way, for those who have a specific problem they want to solve. For example, in an algae frame the salinization of agricultural soils are completely absent from the agenda.

2c. Climate-ready genes: towards a societal agenda

In their new and updated version of *Oogst uit het Lab*, Huib de Vriend and Piet Schenkelaars (2008) set off by remarking that agro-industrial firms have been driven for several decades now by two big motives: globalization

and modernization. The history of the biotech debate makes it clear that these motivations may have sufficed to put GM prominently on the agricultural innovation agenda, but they have not sufficed to prevent a heated debate. This debate has become stuck in repetition and polarization in many ways, yet it also evolves. A shift in the debate that is presently taking place is that issues of power and intellectual property are becoming more central. They are at least in part replacing debates on inherent characteristics of transgenic technology. From the perspective of a robust social and moral agenda, the shift is a promising one. The debate on climate-ready genes immediately illustrates the shift in the debate.

Development of GM seeds is increasingly in the hands of a few very large multinational companies, of which Monsanto is the leading one. ETC criticism does not primarily focus on transgenic technology as such, but on contrasts between the interests of big and powerful multinational companies and those of small and powerless farmers. Ironically, critical NGO's such as Greenpeace and ETC may have unwittingly contributed to the concentration of power, as their opposition has encouraged strict safety regulations, which render the development of transgenic seeds so expensive that only the biggest companies can afford such R&D. However that may be, as biotechnology is expensive and requires expert knowledge and safety measures, it promotes concentration of power. Thus, at first sight, opposition against the power of multinationals aligns well with opposition to biotechnology, while a pro-farmer strategy coincides with an anti-GM strategy. In short, a debate in terms of power and property seems to fit in with familiar GM dividing lines.

But the behaviour of farmers in developing countries, such as India, Brazil and China, turns out to be far more complicated and is now rapidly changing this familiar pro-con GM picture.

Developments in Gujarat in India have been reported most widely. In 2001, the state of Gujarat was struck by a bad attack of bollworms, which infect cotton plants. But some fields prospered, and it was discovered that these fields had been planted with a seed variety that (illegally) contained a gene on which Monsanto had a patent and for which it had been trying for years to get a permission to sell in India. The new variety was banned, but the bollworm-protecting gene did not disappear from Gujarat. Farmers themselves continued to breed with the seeds they saved, and they discovered that the second generation was also resistant to bollworms. Local seed companies rose to commercialize the descendant seeds, and

there is now a thriving industry of Bt cotton seeds. It has been estimated that in 2005, 80 % of the cotton in Gujarat was grown from illicit Bt seeds.

In an article on the situation in Gujarat, in which he calls the Indian breeders and farmers "The Napster pirates of transgenic biotech", Andrew Leonard (2007) writes that if this 'anarcho-capitalism' is an indication of what is yet to follow, then we are bound to see an 'incredible mess': "Corporations will be unable to control how their biotech is used. Green activists won't be able to stop its spread. Governments, no matter how well-meaning, are unlikely to effectively implement biosafety protocols that are 100 percent certain to screen out all possible risks." Yet perhaps, Leonard continues, we need not be dismayed by this mess, since

> "One encouraging lesson is that while the Monsantos of the world are extraordinarily powerful, they are not *all powerful*. Another could be the observation that transgenic biotech can indeed make a positive difference in the lives of farmers, especially when they are given the freedom to experiment and adapt. Yet another is that farmers are not automatically helpless pawns in the face of corporate capital -- they can co-opt new technologies and create new agricultural practices."

Thus, developments in India (and China, and Brazil) rapidly undermine the idea that GM technology is just bad for small farmers, and so undermine the traditional lines of division in GM debates. The new situation requires a more complex analysis, if justice is to be done to a locally variable and overall confusing reality in which safety regulations suffer, patents are undermined, terminator technology may become more attractive for big companies in order to prevent illegal breeding with GM seeds, and GM technology becomes a fact of life, legally or illegally, in many parts of the world.

In this new situation, the question whether, and under which conditions, farmers can profit from GM technology, is beginning to receive new and more nuanced consideration. For example, Ronald Herring, in an article that primarily addresses the situation in Gujarat, also points out that in China both the public and the Monsanto versions of Bt cotton have been adopted rapidly by small farmers (Herring 2007b; see also Herring 2007a). He stresses that this does not point to irrationality on the part of farmers: they have done it for higher yields, less pesticide application, and higher profits. The question whether poor farmers can profit from GM technology has also been addressed in a still to be published study by IFPRI and Oxfam America. One conclusion of this study, on the basis of what is happening in

India and China, is that GM is beneficial for farmers if patents can be circumvented (Bert Visser, oral presentation, June 2008).

While these new analyses agree that GM can be beneficial for small farmers in developing countries, they seem to point in somewhat different directions with respect to the impact of patents on poor farmers. But when it comes to intellectual property, another main observation should be that the field is in great turmoil anyway. Patenting in general, and patenting of genetic material in particular, has become subjects laden with impressive amounts of questions, problems, alternative proposals and new initiatives, including piracies. A fundamental rethinking of intellectual property is beginning to take form in many places, including the patenting institutions themselves. For example, in a report called "Scenario's for the future" (Elahi 2007), the European Patent Office explores four widely different future lines of development concerning intellectual property, of which some involve fundamental breaks with the present situation.

It seems almost certain that intellectual property and power relations will be issues of increasingly intensive debate in the coming years. At the same time, GM technology in the production of food is rapidly becoming a fact of life and a more or less normal technological tool. Therefore, a shift in the GM debate from issues of technology to issues of power and property may help to undo familiar polarizations in the GM debate. The shift might also help in diminishing the technology-driven character of moral debate surrounding GM, as the motivation for the debate on (intellectual) power is primarily derived from social concerns, and is not restricted to GM. If this debate sufficiently responds to empirical complexities and local differences in the world, the shift may add to a more socially robust innovation agenda.

The shift thus opens the prospect of an innovation agenda that is primarily motivated by issues of social problems and injustices, in which GM in itself is becoming a more normalized tool. As a consequence, it may become a matter of relative moral indifference whether saline soils are planted with traditional or genetically modified salt-tolerant crops. The choice may become a more pragmatic one. Innovative frames may profit from this.

3. Conclusions

3a. Saline soils

The increasing salinity of soils is an increasing problem for agriculture, in The Netherlands and elsewhere. A new and realistic view of salinity may

open up an innovative perspective, in which salinity offers opportunities as well as problems. Once this perspective is adopted, it becomes clear that there are many traditional plants that are moderately to extremely tolerant to salty conditions. But in our societal / commercial climate, innovation is associated with new technology. Local and traditional knowledge is associated with counterculture rather than innovation. Innovation and problem solving with the help of traditional technology, though feasible enough in theory, seems to be an uneasy combination in practice.

3b. Algae

Algae technology is still very much in uncertain phases of development. The social and commercial applicability of algae technology is hard to predict; expectations are subject to rapid changes. From the point of view of technology development, this may not be a problem, but from the point of view of societal agendas, embracing immature technology amounts to a choice for random drift. Prominent models of science-society relations in which societal applications are derived from technological innovation fit in well with widespread competitive fears to "miss the boat". For the problem of saline soils, meanwhile, the algae frame does not have to offer anything, at least at this moment.

3c. Climate-ready genes

Debate surrounding GM food is rapidly changing to issues of power and intellectual property.
At first sight, these issues seem to fit in with familiar dividing lines between opponents and proponents of GM, as the interests of big GM companies seems to be opposed to those of small farmers. Given the large scale use of (partly illegal) GM seeds by small farmers in various developing countries, however, GM crops are now becoming a normal fact of life in many parts of the world, and the analysis of harms and benefits becomes far more complicated.

A debate of power and intellectual property that relies on sufficiently complex and realistic analysis is a step in the direction of a responsible societal agenda for technological innovation.
In a world in which GM technology is a normal tool, GM breeding of new salt tolerant plant varieties need not be contrasted with the preservation of traditional varieties. These approaches could coexist harmoniously in the toolkit of innovators and problem solvers.

3d. Final remarks

The returning theme in this analysis is that within our strongly technology-oriented innovation climate, the combination of innovation and traditional technology is an uneasy one. Our society tends to equate innovation with new technology and impatiently projects great expectations and hopes (as well as great fears, hence also: intensive debate) on new technologies. But the strong orientation on promising but unripe technologies generates a very hype-sensitive innovation agenda, which drifts as a derivative of the changing technological and moral vicissitudes of technology. Meanwhile, low tech innovation frames suffer.

Given the need for an innovation agenda that is more consistently geared to societal needs, it is a hopeful development that GM debates are now increasingly focusing on issues of power and intellectual property. If this new debate responds to the complexities of social reality, it can certainly be a step towards a more robust societal innovation agenda which, rather than being derived from the frontiers of technology, builds on a (sufficiently complex) analysis of societal needs. A more robust societal agenda could be more indifferent with regard to the question whether useful technology for purposes of innovation is old or new.

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Appendix 1 – The expert interviews

Joachim von Braun

18 February 2008
Subject: Global Change and food

Résumé

Director General of the International Food Policy Research Institute (IFPRI) in Washington DC, USA, since 2002. He guides and oversees the Institute's efforts to provide research-based sustainable solutions for ending hunger and malnutrition. Before that he was director of the Center for Development Research at the University of Bonn. He has extensive experience in the area of food security in developing countries. He was also professor of Food Economics and Policy at Kiel University, Germany. He received his doctoral degree in agricultural economics from the University of Goettingen, Germany in 1978.

In your view, what are the most urgent problems in the field of food?

"The most important issue in the field of food is the high price. High food prices are an urgent problem especially for the poor people. There has been a major increase in world food prices over the last two years.

Another development is the globalisation of the food system. There is a food system in operation now that requires a global response to supply issues. This global system is integrated in information, trade and technology.

Sustainability is the most desirable development. There is a need for a sustainable management of natural resources on which food depends, especially water, soil, biodiversity and climate.

Rich people don't have urgent problems, except the massive increase of obesity. This is not only an increasing problem for rich and middle-income people. In other words, there is undernutrition and overnutrition at the same time."

What solutions do you see for these problems?

"The solutions are very different. To tackle obesity we need behavioural change and the availability of low cost food with high quality. The problem of undernutrition is a problem of poverty. It is caused by a lack of calories, of healthy micronutrients and protein rich food. That needs to be addressed by policies and programmes, which reduce poverty in rural areas, specifically with agricultural development."

Are there any biotechnological solutions for these problems?

"Yes, biotechnology can and already does play a role. Biotechnology is an instrument to increase the income of farmers. We should define the role of biotechnology from the income perspective of low-income farmers, that is one relevant angle and the nutritional angle complements that.

Biotechnology can play a helpful role in addressing the long-term sustainability issue and climate change. It can help with the problems of drought and heat stress. There is also a strong link between agriculture and the energy sector: biotechnology helps facilitate the faster development of products with a higher return on biomass.

Lastly, biotechnology can be helpful for higher micronutrient content: plants that are richer in vitamin A, iron and zinc. Biotechnology offers significant potential here.

In the perception of many people there is a difference between GMO and other techniques. We have to explain this difference in the debate. We have to continue developing both techniques, depending on the product and circumstances. Biotechnology as such should not be excluded from the options to improve sustainability."

Should biotechnological solutions be placed higher on the social, political and/or scientific agendas? If so, why?

"Biotechnological solutions are already high on the agenda, they don't need to be placed higher. But it is hard to actually influence the position on the agenda. We need to work with all stakeholders to facilitate this agenda setting."

What are the differences between developing and developed countries (in terms of both problems and opportunities)?

"Biotechnology is much more relevant for developing countries, than it is for developed countries. This is because of the emerging consequences of climate change, and because of the existing problems on food scarcity and food quality."

Which developments/solutions do you think will lead to public debate? Where do you expect controversy? How should we deal with these controversies?

"We have been in the middle of the debate for 15 years. We need to deal with this openly and with good information from the research community. It is part of a political process like any other new technology."

In your view, what will the field of food look like in 20 years time?

I think the world food system will be much further integrated from the demand side, that is from supermarkets. The retail sector will be far more powerful. The system will also be more integrated from the perspective of people's taste. Retailers will cater to a lot of diversity, it will look more Western. That was the most important point: a retail driven food system.

The food system will also continue to exclude people. There will be a large reservoir of poor people without resources to buy in the supermarket. They need cheap but healthy foods.

Furthermore, there will be a large niche of eco-products. There will be a large bio-food chain.

Small farms will still dominate the world food system, but in much more effective contract and co-operative systems, thereby linking them to the retail sector.

Lastly, food will focus much more on health in 20 years. The safety of food will be even higher on the agenda."

Which statement/question/dilemma would you like to put to the readers of this interview?

"There is one important dilemma: The fast growth of income in developing countries, which will lead to a fast expansion of demand as in China. In principle this is very good, but this high demand will keep food prices high. The poor cannot afford this. What will become of the poor in this scenario? The dilemma is that we have a large portion of the population left in poverty and on the other hand a better economic situation.

The solution has two elements: The first is a new technological revolution (biotechnology could be part of it) to reduce the supply constraint so that we have more production of higher quality and prices don't increase so much. The second is the expansion of public food and nutrition programs that support the poor."

Cees Buisman

12 March 2008
Subject: Global Change and waste

Résumé

Cees Buisman took his doctoral degree on biological sulfide oxidation at Wageningen University in 1989. After that, he worked at the Dutch environmental technology company Paques B.V. on biological desulphurization of biogas, natural gas, methane from dumping sites, gas from refineries and from combustion, and on biological removal of sulphate and heavy metals from water. Since April 2003 Buisman has been professor in biologically sustainable technology at Wageningen University and Research centre in the Netherlands. He combines this position with his task as scientific director of Wetsus, a centre of excellence for sustainable water technology based in the Netherlands.

What in your view are the most urgent problems in the field of waste water?

"When you look at waste water, with the European Water Framework Directive at the back of our minds, then there are four substances in the removal of which the Netherlands will probably invest: phosphate (a nutrient), nitrogen (a nutrient), copper (poisonous compound) and sink (poisonous compound). At the moment the waste water contains numerous active biological substances that we cannot remove properly, because they are present at a very low level. Since the 70s we in the Netherlands have been able to remove the nutrients that cause growth of algae, and now the poisonous compounds are the problem. That`s going to be a huge problem.

Because slowly it becomes clear what the influence of these compounds is on nature. It is very stealthy and dangerous and we don´t even have the technologies to handle this."

Can you give some examples of the effects on nature?

"Other countries are behind what we have done in Western Europe. The most important thing to do with waste water is remove the oxygen demanding compounds. If you don´t, the surface water will lose its oxygen and everything in it dies. There are many countries around the world that don´t even remove these compounds. The next step is removal of the nutrients. If you don´t do this, it will lead to growth of different small organisms, as we like to call 'green soup'. That soup will decompose and all the oxygen will be removed from the water. This is caused by nitrogen and phosphate and on hot days even in the Netherlands that soup arises in the water. That means we did not remove the compounds sufficiently. The new European Water Framework Directive tells us to do more. After that, you have to remove the poisonous compounds from the water, including zinc and copper. These compounds are not poisonous directly, but accumulate slowly. Copper originates from water pipes and zinc from products like shampoo, zinc roof tops and galvanized crash barriers."

What solutions do you see for these problems?

"For the oxygen demanding compounds there already are different solutions, such as biological water purifications, aerobic as well as anaerobic. New solutions keep coming up, small as well as large scale and with and without membranes. Nitrogen is being removed biologically from waste water as well. The result is nitrogen gas, that in its turn will be converted to nitrogen. Factories have taken this nitrogen from the air before by using a lot of energy. We are now trying to win back the nitrogen from waste water as ammonium instead of nitrogen gas, to use as fertilizer. This could save a lot of energy."

"You cannot decompose phosphate. We can pile it up biologically or chemically in sludge. This sludge can be burnt and that costs a lot of money. Phosphate is a mineral that is extracted from mines and people think we will be short of phosphate in 70 years time. So there is also a lot of attention paid to the reuse of that mineral. The problem is that waste water only contains very small amounts of phosphate."

"Zinc and copper can be precipitated in sludge or it can be burnt. The rest in the waste water must be processed through filtration, absorption or precipitation techniques. Researchers don´t know yet what is the most economical way to do this."

Can all these problems be solved by developing new technological innovations, in your view?

"Yes, I am convinced. The problem is specifically the compounds that are present at very low levels. The question is whether we improve the existing water purification systems step by step, so that we can remove all other compounds after the oxygen demanding compounds, or do we have to work on a totally new concept that will purify the water all at once?"

Are there any biotechnological solutions for these problems?

"The technology to remove oxygen demanding compounds and nitrogen is biotechnological. Sometimes biotechnological solutions are being used for phosphate. But not for all the other compounds, those that bacteria cannot use. To remove these compounds we have to come up with chemical or physical solutions. Or maybe another solution that we don´t know yet. But we don´t use genetically modified (GM) bacteria. Because there already are a lot of bacteria in waste water, it is difficult to keep GM bacteria in a closed system. I wonder if they can compete with existing bacteria. Furthermore, you have to apply for permits to do these kinds of experiments. And it is unclear what the use of GM bacteria means for the sludge you make."

"So far, I have never heard of or seen a project that uses GM bacteria for water purification. Not even for the compounds that are so hard to remove from water. The most important problem is that there are huge amounts of water with very small concentrations of compounds like zinc. Bacteriological purification is not very effective in such cases. That is why we use electrochemical treatments for these compounds."

What are the differences between developing and developed countries (in terms of both problems and opportunities)?

"Until recently it was common in the Netherlands to dump the sewage water in the North Sea unpurified. This is still normal in less rich countries, but also in countries bordering the Mediterranean Sea. Purification usually is only available to rich countries. In countries where sweet water is

limited, laws increasingly demand that it cannot be dumped at sea anymore. In these countries, sewage water is increasingly purified and reused."

One of the Millennium Development Goals is to reduce by half the proportion of people without sustainable access to safe drinking water. How can we achieve this?

"In my view, the water and sewage system we have in the Netherlands is very expensive. Other European countries are less able to develop such a system. I don´t think we can provide the rest of the world with this engineered way of providing clean drinking water. We need a more process engineered approach. Considering a person needs only a few liters of clean water a day, we should develop a method that can provide clean water locally. If you don´t use pipes, you will not develop so much waste water as we do in the Netherlands. One way to do this is to extract water from the air by cooling the air. That is relatively expensive, but if you need only a few liters a day, it is cheaper than constructing pipes. There already exist such systems driven by small wind turbines, thus providing sustainably produced and safe water."

In your view, what will the field of water purification look like in 20 years time?

"We will have developed techniques for the removal of zinc and copper in 20 years time. Furthermore especially the Netherlands will play a role in developing chemical, physical, biological and membrane techniques. The rest of the world wants to provide a engineered solution for drinking water provision, with for example water pipes, but in the Netherlands we are looking for process engineered solutions. This can lead to more small scale solutions than is usual. At Wetsus, a centre of excellence for sustainable water technology based in the Netherlands, we are for example researching how faeces can be collected with vacuum toilets. It is much more efficient to remove nitrogen, phosphate and energy from concentrated faeces and besides we don´t use drinking water to flush. Furthermore it is not necessary to use drinking water of high quality for washing etcetera. We can also use water with lower quality. Especially in countries without an extensive infrastructure and in dry areas we must look for these kinds of solutions."

Which statement/question/dilemma would you like to put to the readers of this interview?

"Do we improve the existing water purification systems step by step, so that we can remove all other compounds after removing the oxygen demanding compounds, or do we have to work on a totally new concept that will purify the water all at once?"

Yves Champey

5 March 2008
Subject: Global Change and health

Résumé

Dr. Yves Champey is a physician with over 40 years experience in the pharmaceutical industry. He started as Medical and Scientific Director, working with Miles, Pfizer and Rhone Poulenc Santé, and he was Senior Vice President, International Drug Development, Rhone Poulenc, from 1995 to 1997.

What are in your view the most urgent problems in the field of health?

"Access to health tools, health research, the results of research especially of biotechnology to developing countries, which represents 90% of the world population. Furthermore we have to make a lot of effort in the prevention of metabolic diseases. For example, we have to research the elements of obesity, the origin of diabetes and health-administration: why aren´t they able to cope with these issues? And we have to educate different groups of the population."

And except for research are there things we already can do right now?

"We need more education, more information and more pressure on the food and agro industry. There are a lot of lobby groups working in these fields and that is where our politicians get their information from. That is a major deficiency in our decision-making systems regarding choices in health, prevention, and research subjects. The same has happened with the tobacco industry for the last 40 years. Most information came from the tobacco industry itself, but we learned that was not enough to make

decisions concerning the health of people. Now we stand for the same in the field of food. We know what we should do, but we do not do it."

What are the lessons learned from the tobacco debate that we can now use for the food industry?

"We know that the medical profession is the last to react on information that is well known. We know that politicians have been very slow to react. We have spent a large amount of funding on molecular biological research regarding the consequences of smoking, when prevention of smoking would have been much more efficient. We know this and can learn from it. It took gigantic effort by some countries over the last 40 years to come to where we are today. And this is still insufficient, because 30% of our young population is still smoking. And now the same is happening with obesity. With the difference that obesity is a problem for the whole world, while smoking was restricted to a rich part of the world for a long period of time. Obesity now is an even bigger problem than tobacco ever was."

What are the necessary conditions for the solutions?

"The first effort is to get a high level of consciousness by politicians about the importance of certain problems and questions, because they make the decisions on for example budgets. So they must be well trained and informed and should know what they are talking about. And they should not base their decisions on papers written by the tobacco, agro or food industry."

Do you think there are any biotechnological solutions for the problems?

"In treatment, biotechnology can contribute a lot; in prevention probably not. We are very far from food with low energy levels in the future. So biotechnology can play a role in treatment. And it can play a role in the production of nutraceuticals, food with medical qualities due to specific nutrients like proteins and amino acids. But it will probably be restricted to rich communities, because it will be a costly treatment. It is difficult to imagine that this will be a solution in developing countries, where obesity is a big problem as well."

Do companies also use GMO with the production of nutraceuticals?

"Yes, but this may pose problems in societal acceptance because of the quality of information we receive. To my knowledge there is no demonstration of risks related to human health in the use of GM organisms in food production. But still the possibility of risk is largely amplified by the media, with no scientific basis. That is the situation we are in now."

"The problems begin with the education of politicians. They should not be under the pressure of lobby groups and advisory groups. They should have a scientific base for their decisions."

"We can deal with this through education and information. It will not be enough, but it is a beginning. Plus we need more research about the safety or toxicity of GMOs. We must get a clear sight on the real situation rather than depending on pieces of information which are biased or misinterpreted. In France the National Institute for Agronomical Research gives scientific information on GMOs, but that institute is totally paralyzed by activist groups. They don't even think about discussing the subject. And that is a pity, because researchers are precisely those able to give the information. I think that France is not the only country where this happens. Politicians sometimes have difficulties resisting these pressures."

Do you think that biotechnical subjects should be placed higher on the agenda?

"Probably yes, because this industry is active, entrepreneurial and explores many different situations. They represent the future of many industries like food, agriculture and health. The resources and means should therefore be more important."

And what in your view will the field of health look like in 20 years time?

"We will probably devote 20% of Gross National Product to health in rich countries. It is difficult to say if the problems I mentioned will be solved. In theory,yes, if education and information improve like we discussed. But we don't know what will happen. There will also be a lot of ethical questions. For example, how should we deal with human population diseases like rheumatology as opposed to orphan diseases, where we have a small group of people having the benefit of treatments that are sometimes extremely expensive? We know that there is no ethical answer to this. And that is why we are going to spend more and more on health. But it the future will be

extremely interesting for some industrial groups for new research activities and new products."

Michel Dutang

11 March 2008
Subject: Global Change and waste

Résumé

Michel Dutang is head of research at Veolia Environnement, a global company offering environmental solutions.

What are in your view the most urgent problems in the field of waste?

"The main issue is that we have to industrialise the valorisation process of materials and energy. We have to transform the old technique of valorisation in industrial techniques. Globally, for instance, the rate of valorisation is 10 to 15 %, mainly because the cost of labour is high and the cost of metal is not high enough. So there must be fiscal incentives to help valorisation. The other point is that you need a lot of research about automation in the valorisation field, because if you want to have a very high rate of valorisation, you must transform all these plants that have manual separation of waste into automated plants. For example in the plant in Great-Britain, where they are able to sort out 100.000 ton waste per year with only 15 people. That is not completely automated, but it is a beginning. There is a lot of work still to do be done."

"This development gives rise to the problem that you get a lot of secondary material on the market that has to be analyzed for toxics, like dioxin. These can cause health and safety problems. Therefore valorisation has to be automated scientifically."

Can you give examples of materials that are important to valorise?

"First organic matter can be used for compost. It has to be purified sufficiently and needs to be separated from the toxic and urban waste for instance. It is easy to make compost, it is quite difficult to make good compost. Therefore we developed x-rays to detect toxic waste in organic waste. The process is the same as is sued for your luggage at the airport, enabling us to produce good quality organic matter."

"Furthermore we can sort materials like paper and plastic, but both quality and quantity are not so good."

"Thirdly the path that is not well developed yet is for energy recovery; to produce secondary energy without producing for example dioxin."

"If you can solve these issues, we do not have waste problems anymore."

How much can we valorise when we apply these solutions?

"I believe we can obtain 40 to 50% in about 10 years. The big problems at the moment are the capacity to sort the materials and detection to increase the capacity of valorisation."

Can you name some necessary conditions for the solutions?

"All waste management companies must develop these technologies, because in 10 or 20 years the prices of materials and energy will be very high. Governments must support these companies to reach their goals, for example by giving fiscal advantages for valorisation. In some countries this fiscal advantage already exists. We work in Southern Ireland where there is a high tax and therefore a lot of advantages for valorisation. So if the rates are high, it is easy to develop new plants and develop the technologies. You can compare it with the efficiency of car engines and the tax on cars in Europe. If the oil price increases, the companies will develop more efficient engines. So the efficiency of the engine in Europe is better than outside Europe. Governments need to change their fiscal policies to avoid prices of materials and energy becoming very high."

Are there any biotechnology solutions for the problems we just discussed?

"In my opinion the future of the treatment of waste or, for instance water is a mix between biotechnological, physical and chemical solutions. Chemical and physical solutions are not sufficient, so biotechnology can be used additionally, for example to obtain high value materials from waste and to convert organic matter more efficiently. For instance for CO2, the solution will be a physical solution with underground storage. Biotechnology will probably be too expensive to develop a solution for this problem. But if you want to transform a part of the organic matter into high value products, of course biotechnology will be very important."

Do you see a difference between GMO and other biotechnological techniques?

"It might be possible to use GMO in the field of waste, but at the moment we are not convinced of the added value. Furthermore, there is a lot of debate in Europe on GMOs. People are very concerned about new techniques of biotechnology. They don´t exactly know what GM is. Therefore we must demonstrate that working with biotechnology is no problem. We have to prove that GM is safe and that we can control the consequences. That way the debate will not get too big. So we have to put resources in research on the impact of biotechnology. If people will refuse to accept the technique, it will become very hard to convince them of the safety."

Do you think these biotechnological solutions should be placed higher on the agenda?

"Yes. For instance for energy recovery from biomass. We urgently need to get proof of principle of biotechnology by working in laboratories in order to resolve the public problem of the impact. And then you can put the products on the market. In France we had some field tests with GMOs, but these tests had to be stopped due to some problems and the public debate. So the first step is to make a study of the impact to demonstrate that it is safe. As with the nuclear plants it is possible to convince politicians and community to start this type of research. Furthermore we have to cooperate with NGOs before we put these products on the market."

Do you think there are differences between developed and developing countries?

"We have developed a lot of techniques in developed countries. These have been enrolled in developing countries. This process becomes quicker and quicker. If we now direct the developments specifically to solutions suitable for developing countries, I think that in 10 years time all countries, developed as well as developing, will have the resources to use the same techniques. But of course not all techniques are useful in all countries. For example gasification is not suitable in Africa, but you can work with purification."

What will the field of waste look like in 20 years of time?

"Currently waste is in the minds of people, because they have to separate waste. I think in 20 years time people have forgotten about the concept of waste, because all sorting will be completely automated and the waste will be collected underground. In countries like Switzerland, Spain and maybe France we can easily produce new products from waste. It will be the same situation for water."

"Also the demands people have for waste management will be changed. At the moment waste management must be safe, cheap and clean. But in the future, people want more transparency for example for the rate of recovery and energy consumption. Waste management companies will be judged by their integration in sustainable development, by the public as well as in tenders."

Do you have any other remarks that you like to add to this subject?

"No not really. Of course in 5 years time our opinion will be changed. We have to re-analyse our strategy, but the big figures will be the same. I hope we will have new discoveries and technical developments that we cannot foresee now. As I told you I am not very convinced of the added value of biotechnology. Maybe in 5 years time biotechnology can demonstrate for instance that it can produce industrialized hydrogen from waste. Today that is a dream."

Hans Eenhoorn

4 February 2008
Subject: Global Change and food

Résumé

Hans Eenhoorn (Netherlands) studied Economics and Business-Administration in the Netherlands and in the USA. In 1969 he joined Unilever where he worked for 32 years, ultimately as the senior-vice president in Unilever's Foods division. He also chaired a working party that developed Unilever's first environmental sustainability strategy.

In 2002 Hans was invited to join the United Nations Taskforce on Hunger, which task it was to deliver action plans to achieve the Millennium Goal of halving hunger by 2015. Two years later he initiated the 'home grown' school feeding programme in Ghana, which led to the foundation of SIGN in 2006. Hans is now a board member of this foundation. Furthermore, he is

member of the international board of SOS Childrens Villages International. In 2007 he was appointed Associate Professor for 'Food security and Entrepreneurship' at Wageningen University.

What in your view are the most urgent problems in the field of food?

"The current developments in the field of food are a great worry to me. At the moment food competes with fuel, but also with feed. Too many food crops are being converted to meat and milk for the rich. By upcoming countries in Asia that will only increase. At the same time food crops, especially corn, are being used for biofuels."

"Most African countries south of the Sahara are net food importers. They will have an enormously rough time, because the world food supplies have decreased considerably and the prices have risen very high. The net food importing countries are hit twice, because they import food as well as energy (except maybe countries like Guinea, Angola and Nigeria that export a lot of oil)."

"The world food supply is historically low at the moment. Any buffering possibility is therefore missing. Good food crops are converted into biofuels with the help of subsidies. The EU has set the goal to add 10% biofuel to transportation fuels by 2015. In Germany farmers get a lot of subsidy for oilseed rape production and in the USA farmers get even more subsidy for corn production. As a result, the availability and the price of food are under enormous pressure. A lot of problems arise in the countryside and in the cities of Africa because of that."

"I find it remarkable that so much farm land is not being used for the production of food crops, but for example for the production of sugar cane for bioethanol and for the production of palm oil for biodiesel."

"We just should not do this. One SUV tank with bioethanol made of corn can provide food for one person for a whole year."

What solutions do you see for these problems?

"To solve the current problems, we must carry out large programs to make small-scale agriculture more productive and to realize a higher yield per hectare. The World Development Report 2008 of the World Bank sees this as

a realistic solution as well. The West must be prepared to invest in these programs."

"We also need improved governmental support. There´s a lot of talking, but there is a lack of action and decisiveness. The means in Western countries do not - or too slowly - become available. The governments in several poor countries are so bad, that any infrastructure is lacking. These countries must be called to account for this. The World Development Report does that, but as with many reports, the action is yet to follow. If the political will is not clearly present, in the South as well as in the West, than the world food supply will remain a problem."

"We must therefore exert pressure on governments to finally go ahead. We must point out to governments that they do not keep their promises. We must also stimulate our governments to remind developing countries of their failure. Up until now that has been unprofitable, but that does not mean we should not continue."

What in your view are the conditions for successful solutions?

"We need sufficient honest political will - especially in African countries south of the Sahara - to improve infrastructure and to stimulate small-scale farming. That occurs insufficiently now. And the Western countries must be prepared both to exert pressure on those governments and at the same time finance these developments."

"Food, feed and fuel are competing elements on the world market of raw materials. The dilemma that results from this must be brought up very clearly. The world deals with this issue inadequately now. If people get a higher income, than they eat differently. The net result is less food, because more food will be used for animals to produce meat and for biofuels. An example: one kilogram of steak is equal to eight kilogram of corn."

Are there any biotechnological solutions for these problems?

"I think that biotechnology can contribute to these problems, as it also written in the World Bank report: do not put aside biotechnology by definition. Biotechnology is not just genetic modification. The consequences of biotechnology for humans are nil. It is completely clear that the GMOs you eat will be broken down in the gut system."

"There is a lot of uncertainty on the long term effects of GMOs, though. We must do more research on cross-pollination between GMOs and non-GMOs. We must deal carefully with GMOs, but not execrate them too much. We need civil legislation and control."

"Biotechnology in itself is nothing new, but genetic modification can speed up normal cultivation practices enormously without us knowing exactly what the long term consequences are. And I am talking about consequences for biodiversity, not about food safety."

Should biotechnological solutions be placed higher on the social, political and/or scientific agendas? If so, why?

"Biotechnology already is high on the agenda, but in an incorrect manner. In the USA there is only attention for the advantages of biotechnology for the producers, but not for consumers."

"It already is high on the agenda of the advocates, they present biotechnology as the technology with only advantages. It is also high on the agenda of the opponents: they want to prevent its application under all circumstances. I would like to see a dialogue on the conditions under which we can use biotechnology to make this world a little bit better."

"I especially see applications in the use of biotechnology for the production of food crops on farm land that now is unfit. This is especially important because of the climate change. Biotechnology must focus more on the development of crops suitable for dry or saline areas. This becomes more relevant as dehydration increases. That would really be an advantage for the world food production. Genetic modification could play a role here."

What are the differences between developing and developed countries (in terms of both problems and opportunities)?

"One thing that history teaches us is that no country has ever developed properly without being able to feed its own population. Economic development starts with a proper food supply. And if a country makes sufficient industrial products after that, the population of that country can grow without producing extra food. The people in that country can buy food on the global market from the profits of their own industrial products."

In your view, what will the field of food look like in 20 years time?

"I have no idea. At the moment food supplies do not develop well. More than 800 million people are starving. The number is falling a bit in some countries, but not in Africa. The world politics should intercede. Agriculture is high on the international agenda, fortunately, but not high enough. I am therefore pessimistic about the world food supplies and reaching Millennium Goal 1:"Reduce by half the proportion of people living on less than a dollar a day and halve the proportion of people who suffer from hunger". A lot of work has to be done and the speed of change is too slow to actually make the Millennium Goals in 2015."

Do you have any other remark on this subject?

"What happens now is insane and immoral. There is obesity and undernourishment. 800 million people greatly lack a lot of things, are too weak to be productive, and die of hunger or disease, while at the same time a great number of people get ill through overweight, cardio vascular diseases and food related forms of cancer. It is a dangerous situation because of migration and the spreading of diseases. It is also economic madness to keep about 15% of the world population outside the world economy."

Which statement/question/dilemma would you like to put to the readers of this interview?

"It is morally inacceptable that one billion people die, while at the same time one billion people eat so much they get ill."

Fabio Fava

28 February 2008
Subject: Global Change and waste

Résumé

Fabio Fava is Full Professor of"Industrial & Environmental Biotechnology" at the Alma Mater Studiorum-University of Bologna in Italy. He graduated summa cum laude in Chemistry and Pharmaceutical Technologies at the University of Bologna and has a Ph.D. in"Applied Microbiology" from the Institute of Chemical Technology of the University of Prague (CZ).

He was visiting professor at New Jersey Institute of Technology and at Rutgers University (NI, USA) in 1993 and 1994. He is currently the coordinator of the Industrial & Environmental Biotechnology section of the Italian Technology Platform on Sustainable Chemistry and he coordinates/participates in several European research projects in the field of biological monitoring and remediation of contaminated sites and the biotech conversion of wastes and agro-food byproducts, wastes and effluents into flavors, microbial polymers and biofuels.

What are the most remarkable developments in your field of expertise, organic waste and soil remediation?

"The integrated valorisation of organic waste streams, in particular of agro food by-products, effluents, waste and surplus, with the production of value-added fine chemicals, materials, biofuels and water is a new and challenging development. Organic waste streams are extensively produced in Europe (about 2,500 millions of tons per year) and they are mainly composed of agricultural waste, garden and forestry waste, sludge, food processing waste and organic household waste (about 1,000, 550, 500, 250 and 200 million tons/year, respectively)."

"Several food companies are currently paying a lot of money for the destruction of their by-products, waste, effluents and surplus. But these are a source of bioactive molecules and biomaterials and, following proper fermentation or bioconversion, of a large array of conventional and new bio-specialties (food ingredients, pharmaceuticals, fine chemicals), biomaterials (biopolymers, lubricants, fibers, pigments, proteins), base chemicals (organic acids, amino acids, vitamins and other metabolites of fermentation) along with biofuels (bioethanol, biogas). Given their biological origin, biodegradability and non toxicity, they are of special interest for the modern food, pharmaceutical, cosmetic, chemical, textile and energy industry. The market of such products is currently increasing enormously worldwide: from 77 to 125 billions € from 2005 to 2010. Thus, the adoption of such strategies for organic waste valorisation can permit significant improvements in the sustainability and competitiveness of the industrial sectors mentioned above, by allowing them to better fulfill Europe's vision of a sustainable and competitive knowledge-based economy."

"However, the costs of technology required for integrated waste valorisation might be high, mostly of the fact that the industry dealing with such issues is still underdeveloped and dominated by processing costs. Such

costs can be significantly reduced by intensifying the research and development activities in the field. The low or no costs of starting material along with the environmental benefits coming from the concomitant waste disposal would mitigate the adverse economical balance of the strategy."

"In the field of soil remediation, the use of biological techniques and tools for both monitoring and remediating hydrocarbons-contaminated sites provide interesting results in terms of clean up efficiency and environmental and economical sustainability. The use of biotech tools and strategies in the field of contaminated sites restoration should be boosted and receive much more attention than it has so far."

You said we have to work more on this subject. How can or should we do that?

"The organic waste and agro food by-products, effluents and wastes are poorly used for generating commodity and specialty chemicals, at least in Italy and some other Mediterranean countries where agro-food wastes are extensively accumulated. Only the production of biogas from some organic wastes is well established, especially with effluents and liquid waste from the agro-food industry."

"We need to demonstrate the performances of the currently available thermo-chemical and biological biomass conversion protocols in the valorisation of waste and the actual impact of such approaches on the suitability, effectiveness and economy of the processes and technologies currently available for biomass conversion. To do this we have to favour the transfer of knowledge existing in the field of organic waste valorisation from the laboratory bench to the pilot scale."

"Another crucial point is the homogeneity of the waste and related streams. They have to be matched and pre-treated before being sent to the valorisation treatment. It is important to get the desired efficiency and reproducibility in the process."

Can biotechnology play a role in the field of waste?

"As mentioned before, biotechnology is crucial in this area. Indeed, biotechnological approaches and tools can permit efficient valorisation and in a sustainable and tailor made way a number of waste streams largely produced and accumulated in the EU."

And the enzymes or microbes applied are genetically modified in this case?

"Not necessarily. We can use conventional enzymes produced by fungi and bacteria; they are largely available at low price in Europe. We can also count on a large variety of robust and specialized"natural microbes" (i.e., bacteria, years, fungi, algae, etc).

"Of course, the use of specifically developed microbes (GMOs) in waste valorisation can provide more efficient and/or better tailored conversions and products, including new chemicals or biomaterials, but the catalysts have to be applied in a closed process preventing any releases of GMO cells into the environment. The poor stability of some genetically modified micro-organisms represents an additional limitation on the use of GMOs in waste streams pre-treatment and biological valorisation."

Can biotechnology also play a role in bioremediation?

"Of course. This is another key issue, because biotechnology can allow us to efficiently remediate a number of contaminated soils and sediments with much lower impacts towards the treated contaminated matrix and costs than of conventional and of several advanced chemical and physical treatments. Therefore the social acceptance of bioremediation is higher than that of other types of treatments; especially when it happens in their back yard."

"Biotechnology can also offer special tools and strategies for an improved and more efficient site monitoring and risk analysis. Biotechnology is not suitable for the remediation of heavy metal contaminated soils and sediments and for the aerobic remediation of highly-chlorinated compounds."

Do you think there are GM bacteria that can be helpful in bioremediation?

"Bacteria can easily be modified. And in my view they can be used in soil bioremediation, but only in bioreactors and well-contained bioremediation schemes and facilities. They might offer a number of advantages: they can perform the complete biodegradation (mineralization) of some pollutants, very specific pollutant biotransformations and conversions and improve rates and yields of pollutant conversion. If we are bioremediating waste by generating new biomolecules and biomaterials, we have to be sure to be

able to separate the final products from the biomass, because we cannot have GMOs in the final products. If there are GMOs in the products, we cannot sell them."

Are there differences between developed and developing countries concerning organic waste use?

"On the basis of my experience, the difference is that developing countries care less about the selective recovery of waste, and therefore the valorisation of different waste streams is difficult to put in practice and be exploited. These countries probably need some time to consolidate their knowledge in the field. However, they generally take all the opportunities they get and they are very often more open to new and more sustainable approaches than developed countries."

"If we are able to convert waste into biofuels, in chemicals and biomaterials we will have two benefits. One is that we dispose of the waste and the other is that we produce biofuels and value added compounds that are useful for improving the sustainability and competitiveness of conventional industry. And this is a key opportunity for the developing countries as well."

And what will the field of waste look likes in 20 years time?

"What I hope is that these ideas of using organic waste streams for producing valorised compounds and biofuels get much more room. There are some FP7 calls dealing with useful waste valorisation through the application of the so called bio refinery concept. And this is a clear and important signal. Many European researchers and institutes will work on this issue. We need some more information on the transferability of the approach and the feasibility of its scale up, but I am confident that in a few years the large scale production of biofuels, chemicals and materials from wastes will be a reality."

Do you have a statement, question or dilemma for the website?

A discussion point could be:
'Organic waste is an opportunity for sustainable biofuel, biomaterial and biochemical production and biotechnology can have a crucial role in this perspective.'

Ian Gust

5 March 2008
Subject: Global Change and health

Résumé

Professor Ian Gust is a medical virologist with a distinguished career in public health, including involvement in the development of vaccines against hepatitis A and human papillomavirus infection and membership of the International Task Force for Hepatitis B Immunization.

Since 'Retirement" in 2000, he has been appointed a Professorial Fellow in the Department of Microbiology and Immunology at the University of Melbourne. In addition to serving on the Boards of several biotech companies, Ian is actively involved with the International AIDS Vaccine Initiative (New York), International Vaccine Institute (Seoul) and continues to consult for WHO.

What are in your view the most urgent problems in the field of health?

"Number one is controlling population growth. We have a plague of people on the planet. It is likely to take 20 to 30 years before we get into equilibrium. The number of people we have now causes enormous health problems because the growth is occurring most rapidly in countries that are least able to provide any reasonable level of health care."

"Secondly the consequences of climate change which are a complicated group of issues. I think there are a whole range of consequences. In most places the major changes will be on the agricultural potential of land, either because there is too much rain or too little rain or erosion. And that has a tremendous impact on nutrition. People will be more susceptible to diseases and the death rate will increase. There will be changes in the distribution of diseases. Some insect-born diseases which are currently relatively uncommon will become more common in more populous areas where rainfall actually increases."

"Third is implementing effective approaches and making optimal use of products that we already have, but which we have not utilised to their greatest effect. For example, there are many areas in which inappropriate diet or use of alcohol or smoking or lack of access to immunisation cause

enormous health implications which are relatively easily addressed with simple technologies or approaches that are readily available, but have not yet been adequately implemented."

"The fourth big challenge is reducing inequality for people around the globe. We have an enormous range of access of existing, successful means for prevention and treatment of diseases. This leads to inequalities in health outcomes. For example, in my own country the differences between health, infant mortality, life expectancy between aboriginal people and non-aboriginal people are as great as between any two populations on the planet."

What solutions do you see for these problems?

"Some of these problems are intractable, unless we are able to function better as a global community. At the very core I think most of the problems are political and economic. As we have seen so often in the last 100 years the countries that are desperately poor suffer enormously from ill-health. As economic conditions improve, so does the health of the population and the birth rate falls. Without any particular campaigns from the government, when the people find out they do not need 8 or 10 children in order to replace themselves or get cared for, they choose to have less children so that they can participate in the economy and have greater personal benefits. Trying to resolve some of the underlying political issues that enable a country to move forward economically is what is at the heart of improved health of the population. There is always a downside of great prosperity that leads to certain diseases. But in general these diseases are less devastating than diseases of poverty."

And when you have to invest in medical solutions, what solution would that be?

"The medical solutions hang of the political solution. They are very much the effect rather than the cause. I don't think that our fantastic transforming medical advances will suddenly cure political and economic problems. For instance in the West we have had the benefits of immunisation for the last 50 years, but it is only in recent times where we have seen economic and political reform in a number of countries that enable these benefits to be realized. In developing countries donors are able to provide certain benefits, but unless this is accompanied by political will, adequate physical infrastructure and an adequate number of trained health care workers, these benefits cannot be sustained."

Do you have specific solutions for the consequences of climate change?

"First some problems will probably have to become worse before people in some very important countries take them seriously. In my country, where it is very dry, the changes are so dramatic that the population is willing to make major sacrifices. Some very polluting and rapidly industrializing countries do not react strongly enough, because the benefits of industrialization are so obvious and the downsides, by comparison, so distant. I fear things have to become worse to get the global commitment for major changes in living and for government expenditure. I think we are moving from a century of plenty to a century of scarcity of many materials that the developed world has taken for granted. Perhaps the most important way of instituting major change is for resources, like water, to be given a realistic economic price. This will change the behaviour of people."

What in your view are the necessary conditions for successful solutions?

"In democracies for the majority of the population the belief that they are essential for their own wellbeing. And in countries that are not democracies for the rulers to believe that it is in their best interest to implement these kinds of policies."

"And in the US which is the worlds biggest user of energy and biggest polluter things have probably got to get worse before the population will recognize that something seriously has to be done. And probably in China and India things will have to get worse before people take it very seriously and make major adjustments."

Do you think there are any biotechnological solutions for the problems we just discussed?

"Technology will provide a component of the solution. And there are a lot of technologies or biotechnologies which will be very important in the future for providing for example alternative forms of energy and more efficient crops. But I think they are enabling rather than transforming. And we need transforming solutions for the politics and the economics."

Can you give some examples of how biotechnology can do that?

"Capture carbon dioxide from the atmosphere. Possible in creation of biofuels and so on. In the field of health the potential of biotechnology is almost unlimited in terms of producing new approaches of prevention or treatment of diseases and even for identification of personalised medicines as well. Those are all advances that we see happening and we can predict many more of the same."

And do you think that biotechnology should be placed higher on the agenda?

"I think biotechnology has an appropriate place on the agenda. I don't see it as a magical solution. Biotechnology will be tremendously important in producing a whole range of approaches for the problems I have mentioned. But they do not need more attention or funding. There is Darwinian process going on that will select those approaches that are the most useful. They get funding from government, venture capital and industry. Some policies are able to direct the flows of this money so that they can go more into the energy or more into the health field."

Do you think there are any solutions that will lead to public debate?

"Yes. There is public concern about anything that involves organisms that are genetically modified and you see that particularly in Europe. There is a real fear, some is rational, some is irrational, about any process that involved genetic modification. There is rational fear about reducing diversity in the environment and about access to certain seeds been via a limited number of for profit companies. The irrational concerns are about the process of genetic modification which ignores the constant selective breeding that is done by nature."

How should we deal with this debate?

"I think it is a matter of gaining people's confidence by systematically introducing the technology and demonstrating its safety. Addressing the real concerns takes time. We can do this systematically and collaboratively around the world so we can learn from each others experience."

And do you see any differences between developed and developing countries?

"The are huge differences. Some developing countries will be able to rapidly make the transition from developing to emerging to developed as

we are seeing in Brazil and India. But in a lot of other, smaller countries that do not have the resources, I think that unless the international community can assist them greatly, the gap will continue to get wider. We should keep doing what we are doing, but more effectively, learning from some of the mistakes that are made in the past."

And what would the field of health look like in 20 years time?

"In terms of the really big issues we will see that the global population is just at its peak or just declining and that will be a tremendously important milestone. I think we will see continued evidence of significant climate change so that the countries that are the most doubting will be convinced that major changes need to be made. I think that we will start to see scarcity of resources like water that we have taken for granted. And there will be a health effect from that. In the developed world we will see even though the government is spending a larger proportion of the GNP on health the outcomes will be minimal. Because fundamental changes to lifestyle will not have been tackled seriously. AIDS will stay a very big, international health problem especially effecting the poorest countries."

Something to say that I have not asked?

"No. I think that the comments I have made are based on what we know at the moment and do not take into account any catastrophes or major changes that might occur in the coming future, like an epidemic of influenza. That could have devastating consequences that you just cannot predict at the moment."

Niels Jørn Hahn

12 March 2008
Subject: Global Change and waste

Résumé

Niels Jørn Hahn is president of the International Solid Waste Association for the period 2007-2008. He has throughout his whole active career been involved in the waste management industry. He has held leading positions in both consultancy companies as well as waste management companies involved in recycling and waste collection. He is well known for introducing treatment and collection technologies, and is one of the pioneers within recycling of construction and demolition waste. He holds leading positions in national and international professional organizations.

What are in your view the most urgent problems in the field of waste?

"These answers will be my personal point of view."

"The most urgent problem is the lack of treatment facilities – in developed as well as developing countries. Nobody wants to have treatment facilities in their neighbourhood. Politicians in many countries do not have the guts to make decisions to establish the necessary capacity. Therefore we see in many countries in the world that too much waste is land filled under outfall conditions, where it causes a lot of health and environmental problems."

What kind of problems do these treatment facilities cause then?

"Environmental problems, often due to uncontrolled land filling where you have no collection of the leaking water coming from the field; where you have no collection systems for the water or methane that is produced when the waste is deteriorated. So you see a high emission of methane to the atmosphere. Methane is more than 20 times more potent as a greenhouse gas than CO2."

How can we solve this?

"Establish treatment facilities. The debate we have now on global warming and global change is a gift to the waste management sector and the politicians. It becomes more and more a public debate. And the waste industry can make a big contribution to the reduction of CO2. This is a big opportunity."

How can the waste management industries do that?

"The companies can not do that alone. But through the infrastructure of waste treatment the industry can do it. Reducing the amount of waste that is going to the land fills and especially to the uncontrolled land fills will lead to a huge reduction in the emission of methane into the atmosphere. When you use waste to produce energy, you will have CO2 reduction and you are reducing your need for other fossil fuels."

"And also when we look on recycling of specific types of waste, the recycled products have a lower emission contribution than virgin material."

What materials are specifically suitable for this?

"If we are looking at household waste the most obvious materials to recycle are paper, cardboard, glass and specific types of metals."

Can you name necessary conditions for successful solutions?

"Political will. In every country there have been plans for new waste facilities. But when the public debate was more based on feelings than on facts and politicians did not dare to make the decisions on establishing the facility you get situations like in Naples. Naples has a shortage of treatment facilities. This is a showcase of the lack of political will."

So political will is essential to establish more treatment facilities, but on the other side people do not want these facilities in their neighbourhood. How can we deal with this?

"We must make sure that the public debate is based on facts and not on feelings. And that is one of the biggest problems, always. Too many people still mention dioxin when they speak about waste-to-energy. But dioxin is not anymore a problem and any expert will confirm that. However, when it comes up in debate and the media show pictures of Soweto and so on, that gives rise to an emotional discussion that is impossible to control by anybody. So the only way is to involve NGO's in the debate about establishing the national waste strategy and the development of local and regional waste treatment plants."

Can biotechnology play a role in any of these solutions?

"It can play a role, but it is not the solution. Biotechnology is not able to deal with the treatment of every category of waste. There are specific categories where biotechnology is a suitable solution and maybe even the preferred one. For instance for bio waste from agriculture and also for specific types of bio waste from the industrial sector, from restaurants, catering and food companies. Biotechnology can play a very logical role. But if we are looking at municipal waste as one category, it can not solve that problem."

Can GMO play a role compared to other biotechnological techniques?

"There are enzymes that are genetically modified to have the right characteristics to deal with that waste. And it is very natural to use them.

They have to be used to be an economic efficient process. You see that in the bio-ethanol process where a lot of these additives are added to further the process."

You think we should use genetically modified bacteria for the production of bio fuels?

"Yes, that is an option and has its advantages. For instance to have a more economical process. With quicker processing and higher energy production."

Do you think that processes that use these technologies should be placed higher on the agenda?

"At the moment it is in the right place on the agenda. Universities, scientists and the pharmaceutical industries already use a lot of resources on biotechnology. There might be a risk in placing it higher on the agenda, namely that too many people, both politicians and managers, will wait for techniques that still have to be developed and use that as an excuses for not doing anything right now."

"We can compare this with recycling. When we talk about recycling, too many people say that recycling will solve all problems. But first we have to establish efficient, basic treatment systems. Another example is that in Italy people say that they have a promising development in biological treatment techniques. So they wait until that is further developed and finished and then they can do it that way. And in the mean time they do nothing. That is in my opinion a big mistake."

What are the differences between developing and developed countries in your view?

"Both in developed and developing countries we see a lack of treatment facilities. The big difference is of course that in developing countries there are a lot of social and health problems caused by not having an efficient collection system and where we have people that exist by sorting waste on the open land fills."

"The social problems will be less when you try to involve this unofficial sector in your official treatments; when they can play a role in these treatment facilities."

What will the field of waste look like in 20 years time?

"I hope we will look at waste as a resource and not as a problem. That we utilize waste as any other resource that could be used for generating both materials used in industry and to produce energy."

"In order to achieve this, we need more facilities. And the public should look at waste as a resource. Not just something they have to get rid of in the easiest way. And that is a task of the International Soil Waste Association. On a local level we promote sustainable solutions by having information materials, seminars and training courses. In the Netherlands we do it mostly through national organisations. The NVRD is a national member in ISWA."

Do you have a statement, dilemma or quote for the website?

"Either accept that your energy production is also based on waste or you will have to consider the waste problems; both when buying your products, but also by accepting much higher costs of waste treatment."

Hans R. Herren

13 February 2008
Subject: Global Change and food

Résumé

Hans R. Herren (Switzerland/USA) is President of the Millennium Institute (MI) since May 2005. From 2004 to 2008 he co-chaired the International Assessment of Agricultural science and Technology for Development (IAASTD). Prior to joining MI, he was Director-General of the International Center for Insect Physiology and Ecology (ICIPE) in Nairobi, Kenya. He also served as Director of the Africa Biological Control Center of the International Institute of Tropical Agriculture (IITA), in Benin.

At ICIPE, Hans developed and implemented programs in the area of human, animal, plant and environmental health (the 4-H paradigm) as they relate to insect issues. At IITA, he conceived and implemented the highly successful biological control program that saved the African cassava crop, and averted Africa's worst-ever food crisis.

Over the years, Hans has moved his interests toward integrated sustainable development, in particular, linking environmental, plant, animal, and human health issues.

What are the most urgent problems in the field of food?

"First of all we have to make sure that we can produce healthy and sufficient food for all, today and into the future. Consumers are becoming more demanding, also in respect to the origin of food and how it was produced. We therefore need to find solutions to sustainable productivity and multifunctionality. It will be very important to adapt to climate change, through crop genetic diversification and improvement, crop diversification and making the farming systems resilient and adapted to the new conditions. We have to focus increasingly on the farming system, as farming is an 'intervention' into the ecosystem, and this has to be done with care, supported by knowledge, science and technology."

"Given that the world population will reach 8 to 8,5 billion by 2050, we need to address the quantity of food too, through productivity increases, as mentioned above, but again, and very importantly, in a sustainable manner."

"With rising food prices, partly because of the use of food crops for energy, but also because of the steady decline of the cereal stockpiles and speculators that are taking advantage of the expected food price increases over the longer term, there is a need to adjust a number of policies. For one, there is a need to assure that the hungry have access to food in the short term, while also taking steps to help with better and more production. Also, it is imperative that policies are put in place to cap the free and wild speculation with the major commodities, which yet again benefits few and hurts the masses. It is immoral that some people are allowed to speculate on what is a human right: access to food."

"Lastly, adjusting trade policies to favour production by small-scale farmers in the developing countries will become more and more important. Presently, the OECD countries are trying to impose trade policies that are not always in the best interest of developing countries."

"The above issues are creating a lot of debates, because of the centrality of agriculture and food in national security and also at an individual and society level."

What solutions do you see for these problems?

"Solutions will come from research and the implementation of the research results; these obviously supported by a policy environment that will promote the new research and then the uptake of the results."

"New research needs to focus on sustainable productivity increase, because it is not only how we produce more, but also how we produce more food in a sustainable way that will matter in the years ahead. We have to get better water and soil management and also look at integrative production systems that maintain diversity and provide the needed ecosystem services. This means we also have to take care of other goods that agriculture produces not only the food, feed, fibre and fuel. I also support the idea that farmers be paid for the ecosystem services, only so can we make sure that they will be taken care of."

"As suggested above already, we also need better integration of livestock into the farming systems. We now have the tendency to separate different agricultural activities (animals, crops, forests, fish farms, etc….). The factory type production of any of the farm products is not the way to go, it creates a new set of problems, like manure accumulation, unhealthy feeding regimes, energy use and the use of antibiotics and hormones, erosion, nutrient leaching and export, etc, which go against the principles of sustainable agriculture. Therefore, we need to integrate much more the farming system into a holistic unit of food, fibre, feed and fuel production."

"I have some specific suggestions to focus our research on:

- The value of ecosystem services. I believe that eventually farmers will have to be paid for this in addition to growing food. This will help farmers to contribute to sustainability.
- Adaptation to climate risk, like crop genetics and on how to improve farming systems to make them more resilient against the extreme weather conditions, like drought or high rainfall. To improve crops is certainly one important aspect here.
- The increase of production efficiency, which means also less external energy input.
- Adding value at the farm level to improve farmer's income. The farmers produce a raw product that will be processed down the road. The problem is that farmers get the least out of the total value chain. We have to bring back value to the farmer, not only to the people in between.

- An increase in crop diversity, within and across species. This will result in better food security and nutrition and adaptation potential to climate change.
- Improving social networks and policies that help farmers to better adapt to climate change. Insurance policies for farmers are helpful to give them a backing for climate risks, both in developing and developed countries.
- The ability to forecast climate variations, so that farmers can be ready and use crop varieties bred for expected conditions in a particular growing season."

"Research is not useful unless it is made available in a format that farmers can use, delivered on time with an option to receive feed back. Therefore, extension services as well as good access to information are important for farmers. The needed ICT infrastructure has to be planned at the same time as research is carried out, so that the two go hand in hand."

What are the necessary conditions for successful solutions? What are the opportunities and threats?

"We have to respect farmers' and consumer's wishes, not follow any particular interest group. People need to have access to unbiased information, the freedom to make their own informed choice."

"Furthermore, we have to find the real cause of the problem since a successful solution treats its cause, not the symptom. Today we spend too much time in treating symptoms rather than thinking first about the cause of the problems and tackling them at the root. We have great scientific capacities, let's use them for uncovering the causes and develop smart solutions, even if these do not lead to great profits for the agro-industry. Food after all is a human right, and one should keep this in mind when seeing agriculture as yet one more way for a few to benefit at the expense of most of humanity."

Are there any biotechnological solutions for these problems?

"There are options in the area of plant breeding, in particular for marker assisted breeding to accelerate selection processes. I really insist on this, because it is a technique that is not controversial, already available, and I think it can help a lot in the whole breeding process i.e., for drought tolerance, to grow crops on acid and salty soils etcetera."

"Another technique may be switching on and off genes, which is less controversial than GM. Although genetic modification may have uses in bio-fortification, the acceptance problem will remain, as in some places it may be accepted and in other not. The consumers' freedom to choose must be respected in all circumstances. Genetic modification should, if ever, only be used following a detailed needs assessment, the evaluation of possible alternatives and their respective costs and benefits, including the externalities. As of yet, we do not understand enough the ecological, health and societal implications of GM crops to be using them as we are. Bt-induced insect and herbicide resistance, are presently the main transgenic crops on the market, and are mostly grown by large scale farmers, with the exception of cotton, which has also been introduced to small scale farmers too. The benefits of these crops accrue mainly in terms of reduced production costs, rather than increased yield. But for many farmers the issue is less the production costs than other issues such as access to micro credit, inputs, information, markets, etc. For transgenic crops as for any other inputs, farmers need to have the capacity and freedom to make their own informed choices, so they need access to solid and unbiased information, and also education."

Should biotechnological solutions be placed higher on the social, political or scientific agendas? If so, why?

"Let's give a chance to more system based and ecological solutions to the problems addressed by today's GM crops. We have solutions to pests and diseases that could be implemented. Should there be a need for targeted interventions against pest and disease outbreaks, there are a large number of bio and also synthetic products that are environmentally benign and also do not affect human or animal health. GM may some day be used on a strictly 'need' basis if at all, and only after much more solid science on their social, ecological and agronomic implications. Again, if we look at the causes of most of our problems, there are non GM, and proven, methods to solve those problems."

In your view, which developments/solutions will lead to public debate? Where do you expect controversy? How should we deal with controversies?

"Ecosystem services payment in the developed countries is a big issue, because it is perceived by developing countries as a subsidy. This must be handled in a delicate way. However, the farmers in developing countries

also have to be paid for ecosystem services. For example the north can pay farmers in Brazil for keeping the forests, so that CO2 can be sequestered."

"Second, trade agreements will lead to new debates. We don't have a level playing field in agriculture around the globe. European and American farmers have already industrialised, benefiting immensely from subsidies and so they out-compete farmers in the south on price. The focus should be on protecting developing country farmers, allowing them to enter the markets. Every country is different, so there is not one single solution that fits all."

"GM crops are controversial and this won't go away fast. It's all about personal choices and people should be given these choices. How this should be done is not clear. GMOs should not spread widely all over the globe without proper authorization and approval by local authorities, farmers and consumers. The freedom to plant non-GM crops needs to be upheld, and farmers that want to use organic or non-GM crops should be able to do so. This is not guaranteed as of yet, as many of the GM crops spread pollen to neighbouring crops, and the cross pollination that results lead to non GM crop contamination, making them unsuitable for the organic market. A further issue is the large number of lawsuits that have already been raised against farmers, whose crops have been contaminated by neighbouring GM crops. All these issues have to be debated intensively in the future and solutions found."

What are the differences between developing and developed countries (in terms of both problems and opportunities)?

"Ecological principles, which need to be followed, are universal, so these apply similarly in both developed and developing countries. In developed countries we have to get productivity more in line with sustainability. We have to reduce inputs. In developing countries it is the other way around: we need more inputs in order to increase productivity and sustainability and to get better farming practices. We have to farm in a way that the soil will be improved over time, for example by applying organic farming principles - not mined of its minerals and organic matter."

In your view, what will the field of food look like in 20 years time?

"There will be a more nature and people-linked type of agriculture. We already see trends in this direction: agriculture that is in harmony with the environment that nurtures it and with a more human face."

"People also want more recreational area. People do not only want to see corn across the whole landscape. People want to know more about what exactly they are eating because of their health and also where it comes from, how it has been grown."

"Eventually, people in the developed countries will have to spend a larger portion of their budget on food, including the ecosystem services, while in the developing countries that proportion will become lower, from a today's high of 75 %, but in the long term it will equalize around the globe at some 30 % or so would be my guess."

Which statement/question/dilemma would you like to put to the readers of this interview?

"What does food, agriculture and the environment mean to you? Do you see a link?
Do you prefer mass produced food that is cheap, anonymous, manipulated to look perfect and devoid of connections with the environment or do you prefer food of quality, with the imperfections of nature, but also its beauty and health rewards, produced locally by people you know that are taking care of the land your children will also want to enjoy. Would you be prepared to pay more for healthy food that is also good for the environment?"

Birte Holst Jørgensen

18 February 2008
Subject: Global Change and climate change

Résumé

Since September 2005, Birte Holst Jørgensen is the Director of Nordic Energy Research, a Nordic research and innovation funding institution, which has been operating for 20 years under the Nordic Council of Ministers. She holds a M.Sc. in Business Economics from Copenhagen Business School and a Ph.D. in Political Science from the University of Copenhagen.

Ms. Holst Jørgensen is an acknowledged expert and reviewer at the EU Commission and several Nordic research funding institutions. She is the

vice-chair of the Mirror Group of the European Technology Platform for Hydrogen and Fuel Cells and a board member of the research program RENERGI, established under the Research Council of Norway.

What are the most urgent problems in the field of climate change?

"Climate change is closely related to the energy sector. The Stern report states that 65% of GHG emissions are related to the energy sector. Energy consumption is an integral part of our economic activities, I would even say that energy is the pre-condition for our highly developed societies. So with improved world economic development like for example in the emerging economies in China, India and Brasil, we also experience increased energy consumption as in the highly developed countries. All in all, these developments have a major impact on the climate."

"The CEO of a large Swedish energy company has said that as part of the problem, the energy sector must be part of the solution. Conventional technologies based on fossil energy are to be made more efficient and cleaner with Carbon Capture and Storage. We also need renewable energy technologies such as solar, wind and bio-energy technologies. This change will not take place from one day to the next. It requires a dedicated R&D effort in new sustainable and affordable energy technologies as well as favourable framework conditions. The easiest and cheapest way to do something is to use energy more efficiently. Denmark is a good example of how economic growth can be decoupled from energy consumption. For more than 20 years, Denmark has experienced economic growth and at the same time stabilized its energy consumption."

How did Denmark keep energy use low? Can the Danes be an example for other countries?

"The short story is that you should have an intelligent mix of favourable framework conditions and longer term research activities. Energy efficiency is primarily about changing people's and companies' behaviour. This takes time and both carrots and sticks are probably necessary. However, research can provide solutions that may qualify people's choice and the realisation of that choice."

What solutions do you see for these problems?

"There is not one solution but several solutions. Denmark offers one example, but I am sure that there are other good examples of how to balance economic growth and sustainability."

Are there any biotechnological solutions for these problems?

"I prefer to speak about bio-energy instead of biotechnology. Bio-energy technologies are very promising. One has to make a distinction between first, second or third generation bio-energy. Biofuels based on first generation technologies use grain, sugarcane etc. The increasing demand for biofuel in for example the USA has led to higher food prices. So the question is if that is good or bad for poor people. Some argue that food is a scarce commodity and should not be used for fuels whereas others argue that this is about access to food. Biofuels based on second or third generation technologies use non-food crops and waste. These technologies are not fully developed and need further R&D before they can compete with first generation technologies in the market. This development may be speeded up when a large country like China states that it will only produce bio-fuels based on non-food products."

"Do GMOs have a role to play in the provision of bio-energy? Two strategic research agenda reports from European technology platforms address this. One report is the Technology Platform Plant for the future and the other is the Forest-Based Sector Technology Platform's 'A Strategic Research Agenda'. As it is highlighted in the reports, Europe has a good starting point for combining genomic approaches with analytical techniques, molecular breeding and biodiversity studies. Public acceptance has to be taken into account. When using GMO feedstock for bio-energy be it for biofuels, heat or power, the question is not whether it is a healthy food product but rather the environmental implications of the GMO production. Can it be produced in a controlled way, will it threaten biodiversity?"

What are the necessary conditions for successful solutions?

"In our highly developed societies with appropriate framework conditions, control and public involvement, I think it should be possible to produce GMO energy materials without polluting the environment and threatening biodiversity."

Should biotechnological solutions be placed higher on the social, political and/or scientific agendas? If so, why?

"The topic is already high on the agenda. Politicians seem positive about biotechnology.
But it is difficult to communicate about biotechnology in such a way that people don´t get afraid of what is going on. It has to do with how people perceive risks. Scientists and other people working in biotechnology are in general very positive towards the use of this technique, because they consider it a technique in line with other techniques used in agriculture and forestry. Risk is thereby perceived as something contained which can be assessed and controlled with the right measures and procedures. Lay persons perceive risks much more broadly and therefore more difficult to manage. Decision-makers need to take this into account."

What are the differences between developing and developed countries (in terms of both problems and opportunities)?

"There is a paradox here. Only recently the EU lifted its moratorium on GMOs and has applied rather strict procedures to get permission to grow GMOs. Most developing countries do not have such sophisticated legislation but are open for unrestricted use of GMOs. Although developed countries may have the best conditions to allow for the use of GMOs, they also have well organised NGOs, informed citizens and others that advocate a 'Not In My Backyard' kind of standpoint. This paradox is not helpful in achieving broader acceptance."

In your view, what will the field of food look like in 20 years time?

"This depends on which actions are taken over the next few years, for example in relation to an international replacement of the Kyoto Protocol. Bio-energy is just one among other sustainable energy technologies. With further development in second and third generation bio-energy technologies, the discussion about competition between energy and food will disappear. We have to develop a good energy mix that is environmentally friendly and gives a reason for people and companies to save energy."

"We need more action to find different solutions. There is no ideal energy mix, this depends on local circumstances. We should not put all eggs in one basket. Building a new energy system is a long-term process that requires strategic decisions."

Do you have any other remark on this subject?

"There is a difference in risk perception between experts and lay persons. This calls for an open and transparent communication. Difficulties should be addressed, not put aside. You can not hide when a storm passes, you have to face it. Technologies must be socially accepted, this also includes GMO."

Which statement/question/dilemma would you like to put to the readers of this interview?

"One has to acknowledge that risk perceptions vary among people (see also question 9). Information, transparency and dialogue is needed to deal with concerns and views of people."

Richard Laing

25 February 2008
Subject: Global Change and health

Résumé

Dr. Richard Laing was a professor of international public health at Boston University School of Public Health before joining WHO in mid 2003 as a medical officer. At WHO, he is responsible for editing the Essential Drugs Monitor and for coordinating training and research related to promoting rational use of drugs in the community. Most recently he was one of the authors of the Priority Medicines for Europe and the World report.

What are in your view the current developments in the field of health?

"The key developments are the emergence of chronic diseases in most developing countries of the world becoming the dominant burden of disease. And we are in the transition for some countries, but for many countries they have gone beyond their transition. So infectious diseases are now less significant and chronic diseases, particularly cardiovascular diseases, diabetes and respiratory related diseases, are of dominant importance as far as that goes. So that is the first point to pay attention to."

"The second one is the growth of global funding agencies like the World bank, the Global Fund PEPFAR and the Clinton Foundation particularly in

terms of HIV, TB and malaria they are willing to put up very large funds of money to ensure that poor people in poor countries have access to essential medicines for HIV, TB and malaria. That is a very large change. We never had such an amount of money available for pharmaceutical expenditures in that way."

"The third area I think which is frequently forgotten is the decline in innovation that we have seen from the big pharmaceutical companies. The number of new clinical entities been registered by the pharmaceutical industry has declined very dramatically since the late 80s and early 90s. And the significance of that is that it means that we do not have the number of medicines coming online that we need to have available for poor people. So, when we say: which of the essential medicines are on patent, then the reality is that there are very few, and the number is decreasing. It is very hard to say with the exception of antivirals which are the medicines that really should be on the essential list of drugs if they were available for cheaper prices. It is very hard to make a case that any truly essential medicine are not on the essential drug list for reasons of costs."

"I think those are three related issues that people need to pay attention to as far as this discussion is concerned."

The first and third development can be seen as a problem. But the second development is quiet good, right?

"Yes. It is a good development so far it is focussed on particular diseases with a high political profile. And in many circumstances these may not be the diseases that a country should focus on. For a country like India although it has 5 million AIDS patients or 3 million depending which survey you respond to, they have tens or hundreds of times more patients of cardiovascular diseases or smoking related diseases or with diabetes. And so in terms of the burden of diseases the displacement that has happened. We have what we call Millennium Goals that almost entirely neglected chronic diseases, particular mental health diseases and diseases related to other chronic diseases. So, there may well be a feeling that the world is doing a lot for developing countries, and clearly they´re spending a lot but are they spending it to the areas of the greatest need? This is a question that easily can be asked for all of the regions of the world except Africa. I think for most of Africa focusing on aids, TB and malaria is appropriate. But applying the same approach to South America or to Asia is far more problematic."

And what kind of solutions do you see for these three issues?

"I think for the changing burden of disease putting an emphasise on prevention and to try to prevent the emerging of cardiovascular disease and to some extent diabetes is very important I think. Trying to shift the funding is often not something that can be done on a global level. It is something we need to shift at the country and regional level. We have to shift the attention of countries and regions to the importance of chronic diseases and the treatment of those diseases."

And the decline of innovation at the pharmaceutical companies, is there something we can do about that?

"Well, I think that the work the TI Pharma is doing in the Netherlands has a lot of promise and it is investing in the higher risk research areas. I think what has happened is that the pharmaceutical industry has become very risk averse and part of the reason for that are the regulatory requirements of the regulators that pushed them down this direction. But what I think we see with the TI Pharma is the willingness to invest in the science that is far more risky and far less likely to achieve outcomes. That it is in these investments in these high risk technical areas that we will see major innovations happening. I think that the regulatory barrier to innovation is a problem and I think that the reason for that is a lack of attention to the pharmaco-vigilance for post marketing evaluation of medicines. But safety cannot be guaranteed trough clinical trials and through phase II and III trials. And we really need regulating agencies that need to grasp that concept and require, under all circumstances, conditional release that all medicines should be considered unsafe for at least 3 to 5 years after release."

"I argue for a publically funded post marketing surveillance system where all exposures and adverse events for these new medicines would be tracked. So, in developed countries wherever they are prescribing or clinical databases these should be linked for these new medicines. And in developing countries where new anti malarias or new AIDS medicines or new combination therapies are released we need to set up sentinel surveillance systems so that when people are exposed to these medicines clinical events that they face should be reported."

"If we have that then there could be clearly in the companies interest to release medicines where they are unsure about the safety of the medicines but they would be aware that the medicines would be actively tracked. So

that we wouldn't have a Viox disaster or something like that. The problem we have is that the FDA has been leading the way of trying to assure that the medicines are safe for registration and then ignoring the medicines after registration. The EMEA has a much better approach of trying to promote pharmacovigilance and post marketing surveillance. And this is clearly to the benefit of pharmaceutical industry if there is public funding for this process. It makes no sense to have every single pharmaceutical company setting up his own unique post marketing surveillance system where they use common sources of information."

Do you know how pharmaceutical companies think of this system?

"Well, the pharmaceutical companies at the moment are required to do the extensive phase II and phase III clinical trials that are very expensive and take a long time. Now they are concerned to be asked to spend a lot more on unique phase IV post marketing surveillance. So they are resistant to it. The argument that I have made to regulators and particular EMEA which got a lot of acceptance is to reduce the requirements for phase II and phase III. Put public funding into phase IV and allow companies to release products on the market earlier, but allow products that are clearly labelled as 'not yet proven safe' which in fact all new medicines are when they first come to the market."

Do you think that biotechnology can play a role in these issues and solutions we just discussed?

"I am very sceptical of biotechnology, because of the costs of manufacturing biotech products. If the cost of manufacturing a product is directly related to molecular weight of the product: the larger the product, the more expensive and difficult is to manufacture, the less likely it is that you have generic companies that entering the market of that. I think for diagnostic biotech products are far more likely to be successful by using biotech products to identify genes or metabolic defects. I think that is an area where they have real promise. I think for therapeutic agents the costs of manufacture is very high, even for the richest countries in this world."

Can you tell a little bit more about the role of biotechnology for diagnostics?

"When you´re looking at particular diseases where there is range of responses up until now people have tended to look to these responses and

say 'Oh, that is the normal variation.' But it is very likely that you have the range of type 1, type 2 diabetics where all hyperglycemics are required. But what you also find is that those type 2 diabetics end up needing insulin. So, diseases may well progress in different ways but they may well be different forms of diabetics or different forms of asthma and need different treatments rather then treating all the diseases the same."

Are there any other applications of biotechnology in the field of health that may be helpful?

"I think biotechnology and agriculture is of incredible promise for nutrient and food supplies in all sorts of different environments. But that is a very different and indirect approach. In health I remain sceptical. Another point is that the more specialised the treatment is the more expensive the unit cost is. We have seen this with orphan diseases. The cost to develop the medicine for 5 thousand patients is the same as the costs of developing a medicine for 5 million people. Spreading the costs over a few patients will drive up the costs for developing the medicine."

What do you think about the pharma crops?

"I am a very strong supporter. We´ve always had plant breeding and forms of biotech in plant breeding at the plant level. For instance many of the tea plants of the world all come from a single original crop."

Can you name some necessary conditions for successful solutions of the issues we just discussed?

"A more flexible, regulatory environment, particularly with an investment in the public post marketing surveillance for the safety of the products. Because it is totally unrealistic to think that clinical tests can provide adequate safety information. And people can live in an unsafe world as long as they know. But as long as regulators or companies spread messages that all the new medicines are safe, we should address this. I am in favour of using the existing molecules and to fixed dose combinations, for example the poly pill, combination of four different medicines useful for patients that had a heart attack, is a very sensible innovation that should be pursued and followed up."

Do you think that biotechnological solutions should be placed higher or lower on the agenda?

"For therapeutics I think they should be placed lower. The research is expensive and the likelihood of success is low. At the diagnostic side I am much more open to use biotechnology for improvements and treatment monitoring."

What in your view are the differences between developing and developed countries?

"It is easy to lump developing and developed countries to a single package. But the reality is that developing countries are very varied. China and India are developing very fast, but are still considered developing countries. What we see in these countries is a middle class very fast emerging with populations in excess to the whole of Europe. And they are suffering from chronic diseases and are facing all the mentioned problems. So within developing countries there are as many health problems as in developed countries."

In the field of health biotechnology, are there any issues that will lead to debate?

"In developing countries very little. The mass hysteria about gene technology and agriculture is much more likely to be significant than biotechnology in the health field. The rich people in developing countries will call for access to the products of biotechnology, but the inherent costs of those will mean that only the ultimate elite with a special health insurance can have this access. Five or ten years ago I was much more positive about biotechnology. But now I am very sceptical. And if it´s not going to make a difference, it´s not going to create a debate."

What will the field of health look like in 20 years time?

"In Asian countries, Latin America and South Africa the chronic and infectious diseases will be handled quite well. The Haiti's will remain poor, but we have seen dramatic developments in Caribbean countries. I think the biggest health problem in the world in 20 years time remains Africa. The population in Africa will remain about 10% of the world population so is relatively low. But in terms of mortality and early death Africa will remain the area of greatest concern. A successful vaccine against malaria may dramatically transform of Africa, but vaccinations for TB or AIDS I do not think will be successful in twenty years."

"The chronic diseases will likely to be treated with the same medicines in 20 years time as we do now. You don´t develop resistance to these medicines as you do to antibiotics."

Do you have any thing to add?

"I think it is important to understand that innovation is not just product innovation. We need innovation in supply systems, in patient information, in public information and in regulatory systems. All these could have a profound effect on the treatment of people with common diseases. We should not only look at the innovation beyond the product focus, but also beyond the health system and the product, how do they relate? And if we look at biotech we should do this in relation to the health system."

Susan Leschine

21 February 2008
Subject: Global Change and climate change

Résumé

Dr. Susan Leschine is internationally known as a leading authority on the biology and diversity of cellulose digesting microbes, and currently holds a senior faculty position in the Microbiology Department at the University of Massachusetts, Amherst. Her research formed the basis for the foundation of SunEthanol, a company that turns biomass (plant life) into ethanol.

What are the most urgent problems in the field of climate change in your view?

"I feel that the links between fossil fuel combustion, climate change and global warming are compelling. We urgently must limit greenhouse gas emissions. This becomes more and more evident with each new report; for example, a report in the Proceedings of the National Academy of Sciences in the US that carbon dioxide emissions are growing more rapidly than anticipated and the ability of the land and oceans to absorb carbon dioxide from the atmosphere has diminished. This is the most urgent problem."

"Also, from the point of view of energy security in different states and countries, reducing dependence on fossil fuel is an important issue. Oil drives the economy in the US. Political decisions are often based on our thirst for oil."

And what kind of solutions do you see for these problems?

"For limiting greenhouse gas emission the most obvious and immediate solution is limiting emissions due to transportation, domestic use and industry. We must also find alternatives to burning fossil carbon (coal and oil) and we need to develop renewable, sustainable sources of energy."

"I am specifically involved in developing alternative transportation fuels to reduce the use of fossil fuels for transportation. The only form of energy that can contribute substantially to fulfilling transportation fuel requirements at costs competitive with fossil fuels is solar energy captured by plants and stored as biomass. At present, plant biomass is the only significant source of liquid transportation fuel that may replace the world's finite supply of oil."

Do you think we can use solar energy directly?

"Yes, for generating electricity. But currently solar electricity is expensive and will require improvements to bring down costs. The technology for electric and hybrid cars is still being developed. As of now, electricity is not cost-effective for transportation. Our transportation infrastructure depends on liquid fuels."

"At the moment getting to more sustainable liquid fuels for transportation is only possible by converting biomass into fuels."

In your opinion, what is the best way to convert biomass into biofuel?

"This is an area where we are still developing the technologies. At present, most of the biomass that is converted into transportation fuel is plant material that has other uses. This becomes especially problematic when the other use is food. Currently in the US biomass comes from corn. However, we are developing new technologies that make use of the whole plant, especially the parts that are now considered to be waste. The development of cellulosic ethanol as transportation fuel is my specific interest. This is the direction we should take, I think."

"There are many potentially good technologies. We have not yet identified which are best. To be economically viable, they still need governmental subsidies and assistance of various sorts. Therefore, we should examine all alternatives. I focus on a biological conversion process using microbes to

convert biomass into fuel. But there are also chemical conversion processes. We need to explore all opportunities until it becomes clear which technologies will be cost effective in each particular situation, depending on the biomass input."

What do you think are the necessary conditions for these techniques to be successful?

"The advancement of effective new technologies requires resources. Much of the development is still at the basic research level. To develop biomass fuels, cellulosic ethanol specifically, will require additional resources. In a more general sense, I think a necessary condition for realizing success is the general recognition by the public of the overall problem of global warming and the need for solutions. This is necessary in order to make the required investments politically acceptable. Scientists can play a role here: we must explain our work to the public. We need to find the right solutions, politically acceptable and environmentally friendly solutions."

Do you think biotechnology can contribute to the solutions or techniques you mentioned?

"Absolutely. The development of biofuels certainly could involve biotechnology. As I mentioned, there are two biomass conversion methods, chemical and biological. Biological conversion uses microbes and enzymes to convert biomass to ethanol. Basically, this is biotechnology."

Is there a difference between the techniques of biotechnology?

"Interesting question, because for the general public, biotechnology often is synonymous with genetic modification. But the field of biotechnology is much broader and does not necessarily involve recombinant genetic techniques. To give you an example: the technology I am working on with SunEthanol is based on a microbial fermentation of biomass. And one of the ways in which we can advance the technology and improve it is by doing something called 'adaptive evolution'. This means that we grow microbial cultures on a particular form of biomass, and we select the microbes that grow the fastest. We use processes that occur naturally in bacteria and select those with the improved properties. You can use this technique to identify genes that change over time, to better understand the cell metabolic processes. There are many forms of biotechnology that we could use. Sometimes we use techniques of DNA manipulation, but use of these

techniques does not automatically mean we end up with recombinant organisms or GMOs."

Will this lead to more public debate?

"I am sure it will. But the debate should focus on the science. There is no evidence that the use of biotechnology is necessarily detrimental, and there are ample examples of beneficial outcomes. I believe that we must focus on how biotechnology is used, rather than whether or not it is inherently bad."

Can you tell us if there are differences between developing and developed countries?

"It is clear and obvious that there are enormous differences among developed and developing countries. Both the problems and the solutions will vary depending on particular circumstances. And the solutions will depend on the resources available. For example, Brazil is almost independent of imported oil. This was helped by a decision made years ago to focus on cane ethanol. Now Brazil is a leader in biomass ethanol production. Approaches have varied enormously from country to country. Impacts of global warming will vary among countries and the ability of a country to absorb these impacts will vary. In general, developed countries have more resources to overcome some of the impacts of global warming than developing countries have."

But if you look at, for instance, the debate about fuel and food maybe you can elaborate more on that debate?

"This is a very important and serious issue. Certainly, we should work to avoid using food to make transportation fuel. It is obvious that this issue should be examined on a global scale. We need to come up with global solutions such as cellulosic ethanol and biomass products that do not use food crops. This will happen in time."

"But at the moment we are using food crops for ethanol production and this is being debated in the media. For instance, the news media lavished considerable attention on a recent US report, which concluded that corn ethanol has already impacted land use change. There were many criticisms to this report, but the news media did not cover the subtleties of the issue. The news media have an obligation to follow the science thoroughly and

accurately. If they do not, there are negative consequences for society."

"It is essential that we move to non-food sources of biomass as soon as possible. Although corn ethanol is not perfect, it represents an improvement over burning petroleum. I believe we cannot give up on such solutions because they are not perfect. We need to look at them as stepping stones to better solutions."

What will the field of climate change look like in 20 years time?

"In 20 years time, to be optimistic, although global warming effects will be worse than today, we will be on a path to controlling greenhouse gas emissions."

Do you have any other remarks that you like to add to this subject?

"I would like to mention a grassroots educational initiative in the US called 'Focus the Nation'. It does show that in the US there are people who think about the problems and propose solutions. The initiative proposes a '2% solution' meaning a 2% decrease in greenhouse gas emissions for the next 40 years. This initiative puts global warming in perspective first of all. It helps to focus our nation on the issue and suggests solutions. It's encouraging."

"Furthermore, we must recognize the need for major lifestyle changes to reduce global warming, and we need to develop new technologies to address climate change and to find renewable and sustainable sources of energy."

Are there any initiatives in the US that promote a lifestyle with less energy use?

"At the state level there are various tax incentives for renewable energy. But there is no coherent policy. California has been quite successful in initial attempts to control the use of resources through the policies of Governor Schwarzenegger."

Do you have a statement, question or dilemma for the website?

"What will it take to reach a global consensus on the severity of the impact of climate change in order to develop the political will to find real solutions?"

Martin Parry

7 April 2008
Subject: Global Change and Climate Change

Résumé

A specialist on the effects of climate change, Martin Parry is Chair of Working Group II of the Intergovermental Panel on Climate (IPCC) which is concerned with impacts, adaptation and vulnerability. Prior to that he has been Professor of Geography at the Universities of Oxford, University College London, Birmingham and East Anglia. He has won a number of awards, including the Order of the British Empire in 1998 for services to the environment and the World Meteorological Organisation's Gerbier-Mumm International Award in 1993 for contributions to research on climate change.

What are in your view the most urgent problems in the field of climate change?

"In my view the problems are twofold. First, making decisions within the next two years regarding international reductions in emissions and a strategy to deal with it over the next 20 to 30 years. This should be included in the Bali roadmap, the successor of Kyoto. The beginning of action is now necessary."

"Second, an internationally agreed set of implementation plans for adaptation. And that is where GMO, I think, is important. Because adapting agriculture to a dryer world on the whole means developing crops that are less water demanding. In order to succeed in making these adaptation plans, a funding strategy should be developed to particularly target those regions that are most vulnerable. The implementation of this strategy is local of course. Adaptation to climate changes is always local."

What solutions do you see for these problems?

"For the mitigation strategy we probably need 60 to 80% reduction in current emissions in order to stabilize climate change. This is to be realized by the beginning of the next century. If we achieve an 80% reduction we

might be able to minimize the global warming to achieve the EU target of 2°C. But since this implies more radical actions then is the case now, it is more reasonable to say we might minimize global warming by 2.5°C."

"For the adaptation plans it is important to realize the impacts described by the IPCC in the Technical Summary of Working Group II. We should act now to be ready for an increase of 2°C before the consequences build up into something that is unacceptable in terms of loss of human life or reduction in net incomes."

What are the necessary conditions for successful solutions?

"Firstly, there should be international agreement on the problem. This has now been almost achieved. Secondly, there should be international agreement on the actions, and the timing of these actions;this needs to occur in the next 18 months or so, between now and the build-up to Copenhagen."

"Once these two major solutions are achieved, you can put in to place the specific actions. For instance, we need a coordinated global research effort on food crop breeding for climate change. Two types of research are needed;for traditional breeding, and for genetic modification. We need to characterize future climates for the most vulnerable regions, and we need to start developing hybridization of current cultivars or the development of entirely new cultivars. An example is the new CGIAR research plan which, I believe, aims to put about 15 million US dollars a year in to such work.

Are there any biotechnological solutions for these problems?

"Yes, I think there are. Biotechnological solutions are important because some farming systems, which have developed in tune with current climate, cannot easily be modified to adapt to climate change without the help of biotechnology. In some parts of the world we must expect new climates that don't exist anywhere else and for which crop plants have not naturally developed, because their environment hasn't existed. So biotechnology can help do two things. Firstly, it can protect against the negative impacts. This means we need specifically drought resistance crops, because some parts of the tropics, particularly the semi arid tropics, look likely to become even more dry because of higher rates of evaporation and transpiration. Secondly, we need crops that can take advantage of the potential benefits. For instance, warming in the mid- to high-mid latitudes will result in longer growing seasons and longer light conditions."

Should biotechnological solutions be placed higher on the social, political or scientific agendas? If so, why?

"I think that biotechnology deserves more attention, because biotechnological solutions are going to be very important for us to meet the challenge of climate change, they therefore need a higher profile."

Which solutions do you think will lead to public debate?

"We should show the general public that genetic modification can also serve to preserve the environment. At this time the public often only sees that genetic modification does harm to the environment, but this is not always the case. Research could contribute to this debate."

What are the differences between developing and developed countries (in terms of both problems and solutions)?

"The urgency of finding solutions is greatest in developing countries;because the regions where more drought is expected mostly exist within developing countries. Examples are the North and South parts of Africa, and some parts of Latin America. But the geographical location is much more important than whether or not a country is developed."

In your view, what will the field of climate change look like in 20 years time?

"If it is not radically transformed, we are going to be in trouble. By saying this, I mean that if we haven't taken concrete actions by then, things are going to be even more difficult. Furthermore, I hope we have a better knowledge of the change in weather patterns and how this will affect day to day weather events. This will enable us to breed more suitable crops. But we have enough information to act now, so that's what we have to do."

Monkombu Sambasivan Swaminathan

18 February 2008
Subject: Global Change and food

In your view, what are the most urgent problems in the field of food?

"There are many developments in the field of food. The most important is the rising cost of food (like grain and corn). This is due to the rise of

biofuels and the increasing competition between fuel and food. This has become a very important cause of debate.

The second important area is climate change. The change in temperature results in changing rain fall patterns, the melting of glaciers and the rise of sea levels in coastal areas. This has a potential impact on the production of basic food grains. These areas are related, because energy costs have gone up and as a result farmers are attracted to the production of biofuels. They use land not for food production but for fuel crops production. All this leads to issues on food security.

The third problem I would like to mention is that of transboundary pests. The world is becoming a global community. Aircraft are going around the world, birds and people are migrating, taking diseases along with them; avian influenza, pests and diseases.

These are the triple major challenges of today."

In your view, what solutions may be involved? Why?

"We should not change the use of dry farm land from food crops to fuel crops. We should use agricultural biomass that is cellulosic material to produce biofuels, methanol etc., because the human body cannot digest cellulose. Non-cellulosic material we can convert to biogas.

We should also invest more in renewable energies like solar, wind, wave motion and thermal energy. We can use solar energy much more widely and effectively. We should use photosynthetic pathways of development more for food and nutrition security, not for fuels. For energy security we should develop an energy mix, involving solar, wind energy, biomass and biogas.

In the area of global warming and climate change we have to prepare ourselves to meet three different kinds of situations. Temperature increase (more transpiration and evaporation), more water because of frequent floods, melting snow and heavy rainfall and more drought."

What are the necessary conditions for successful solutions?

"We need careful action-reaction analyses to get a better view on how to minimise risks and maximise benefits of biotechnology. Information on these topics should not be put under the carpet. Furthermore, we have to accept that some results and risks cannot be predicted.

Scientist should look at the risks and benefits in an objective manner. The moral responsibility of the scientists and the consequences of their work have enormously increased. Bio-ethics should be a compulsory topic at today's schools."

Are there any biotechnological solutions for these problems?

"I can give you three examples how we can enlarge coping capacity with research.

1. Climate change results in drought: moisture stress because of higher temperature and lack of rainfall. We must therefore develop less water demanding plants. By shifting crops, for instance by growing sorghum, which is more tolerant to high temperature and less water, these new circumstances can be tackled. There are also a lot of old forgotten crops that require much less water than the crops we use today. We should use these natural variations in nature to breed new crops.
2. Biotechnology can offer new ways to address climate change. Drought tolerance can be built into crops, for instance rice, by transferring genes.
3. To cope with sea level rise we can take genes from mangroves that are tolerant to salt. Furthermore we have to develop bio-shields. Just as the dikes provide physical shields, bio-shields are natural barriers to rising sea levels, like mangroves and halophytic plants.

If we combine traditional and modern technologies (like GM and marker assisted selection), combine molecular and Mendelian breeding, we can open new opportunities. Within the research programme we should anticipate the crops we need and the genes we want to transfer. We have to find the best fitting solution for each problem.

Floods can be addressed by exploiting floating rice. These plants are able to accommodate changing water levels."Nature provides for everybody's needs, not for everbody's greed", said Mahatma Ghandi.

Rice is going to be the saviour for humanity in the context of climate change. This crop is well equipped for changing climate conditions, like change in latitude, altitude and temperature. There are more than 100.000 different varieties in a gene bank. This makes rice applicable in almost every circumstance.

The solution for tackling transboundary pests is to build a global village with international screening facilities for identifying genes. Biotechnology is very important here, because we do not know about resistance. People are killing the birds and cows to prevent the spreading of the disease. There are a lot of local varieties, I'm sure some are resistant to infections. I would suggest to execute experiments in quarantine remote islands off the coast of India in order to select useful varieties. Killing the animals is not the answer. Transboundary pests should be monitored and can be better stopped that way."

In your view, which developments/solutions will lead to public debate? Where do you expect controversy? How should we deal with controversies?

"There is a lot of fear, especially with non-governmental movements in Europe. We should trust the scientist with considering the risks and benefits, although we cannot predict everything. The food versus fuel debate will go on for some time."

What are the differences between developing and developed countries (in terms of both problems and opportunities)?

"I have discussed general problems that apply for all countries."

In your view, what will the field of food look like in 20 years time?

"If we are all wise today and we have international co-operation, we will see what we call sustainable food security. Food for all and forever, in an environmentally friendly and socially sustainable basis: the evergreen revolution. I call it an 'evergreen' revolution, because 'green' revolution is criticised for its potential environmental and economical difficulties. 'Evergreen' is defined as productivity in prosperity without ecological or social harm.

In 20 years there will be more international co-operation and a sustainable agriculture. Also, the knowledge on vanished crops will come back resulting in a spectrum of crops to choose from.

The interaction between biodiversity, biotechnology and business, if it is used safely, should lead to an era of biohappiness."

Which statement/question/dilemma would you like to put to the readers of this interview?

"A major dilemma is: there is less and less dialogue and there are more and more opinions. We do not require confrontation, but consensus. We all want food for all and forever, but how do we achieve it? Going back to the past is no option: we should not glamorise the past and shouldn't run down the future. We must blend the tools of traditional wisdom and modern science, this will lead to an era of biohappiness."

Marcel Tanner

20 February 2008
Subject: Global Change and health

Résumé

Marcel Tanner is Director of the Swiss Tropical Institute and Professor of Epidemiology and Medical Parasitology at the University of Basel and at the Federal Institute of Technology. He obtained a PhD on medical biology from the University of Basel and a MPH from the University of London.

Since 1977, his research ranges from basic research on the cell biology and immunology on for example malaria to epidemiological and public health research on risk assessment, vulnerability, health impact and district health planning. His research, teaching and health planning expertise are based on substantial long term experience from working in rural and urban areas in Africa and Asia.

He acts as advisor on communicable diseases research and control, health systems strengthening and capacity building in various national and international agencies/bodies and in boards/committees such as Swiss Academy of Science, WHO and DNDi.

What are the most urgent problems in the field of health?

"In the field of global health the problem is not so much one single specific disease but the health systems that can not cope with the disease problems that we face in different areas of the world. Now the biggest problem is not the focus on one or the other disease, but that we have weak systems. That is actually in global health and health development one of the most urgent problems that we have to tackle."

"Nowadays, within each country we have certain health systems. By health systems I do not distinguish between the public or the private. I mean all partners contributing to better health. So it is the public, traditional, private and charitable system as well as civil society. This is where we see the mismatch. Poor health systems do not recognize the disease problems. Sometimes it is because they are not very well developed or on the periphery. Or there is no good collaboration between the different service providers."

"So it is not only a question of money. The different health systems of our world are faced with many differing problems. If you look carefully at health systems in the world you see relatively rich countries that have poorly performing systems. Like the US that is investing quite a lot of the GDP into health, but the system is not performing very well. Indicators such as mortality rate and lower life expectancy are for some areas of society similar to those in developing countries."

"It is not only the organisation of a health system that is responsible for identifying priorities, allocating resources and really pursuing the implementation of health plans. It is also the structural and functional status of health systems which I think are the most critical issues of this world."

And what kind of solutions do you see?

"One of the solutions is to introduce a more systematic approach. In health planning many people are focusing on an epidemiological approach by looking which are the most important diseases. It is important that we tackle pandemics like HIV, but if you tackle it in a mechanistic, 'magic bullet' approach, then you will not succeed if you do not have a system to carry it through."

"An important problem of weak health systems is the human resources. If you really look at for instance the Millennium Development Goals, where everybody is focusing on 2015, and you calculate what you need in terms of people working in the health sector on different levels (medical doctors, directors, etcetera) you will find that most countries have substantial deficiencies in human resources - preventing them from reaching these noble goals. So, even the best plans will not work when human resources are not available."

And what in your view are the necessary conditions for successful solutions?

"The necessary condition is to have a comprehensive approach to health and disease, and health and wellbeing. Too many countries are very much focused on disease problems as a means of achieving good health and less on health systems that can provide the available tools like vaccination for the population. It is a paradigm shift that I will explain to you with a very simple comparison. Too many people talk about 'magic bullets' to treat diseases. What you need is the magic gun. And the magic gun is a functional health system. If you want to have long term success, this change is necessary."

"Short term success by way of reducing a disease, having an impact through prevention, that is always possible. But it is not a recipe for the long term success of a system that cares for the health and well being of a population."

If you would set short term goals, which goals would you set?

"Assure that in each geographical setting (north, south, west, east) that the health system can deal with basic treatment and prevention. Emphasise vaccination to ensure treatment at the centre and at the periphery. You will not get the commitment of a population if you work for health issues on the long term, whilst ignoring the immediate, basic needs. If your emergency system does not work, if the vaccination for the children is not working, you can never achieve desired goals in the long term."

"Vaccination is one of the most important basic needs on the prevention side. On the treatment side we are turning back to what we tried in many resource poor countries: to formulate essential programmes, so that at the peripheral health facilities you can diagnose and treat a common disease pattern. That is very important and these systems have broken down in many countries where minimal essential treatment kits disappeared from the periphery and can only be found in central health units. By reinstalling these basic, minimal essential kits common disease problems can be diagnosed and cured."

Can biotechnology play any role in these solutions and problems you just mentioned?

"Biotechnology can play an important role. But not with the single philosophy that biotechnology will be that magic bullet. You still need the magic gun, the health system. Biotechnology can play an important role, particularly on the diagnostic front for instance, at the site of care diagnostics. Biotechnology can do a lot of good."

"For example, a big diagnostic problem in many countries is to distinguish the origin of different fevers. Because many viral infections spread to new areas. We have to make the right diagnosis at an early stage; for example with stick-tests at the point of care. Such rapid diagnostic tests are very important for rapid and correct diagnosis and care. Even if you have no treatment for a particular disease you must exclude some diseases.

Do you think biotechnology solutions should be placed higher on the agenda?

"In some circles biotechnology is rated high. I think you can only look to biotechnology in specific situations. In resource poor settings the biotechnology from the peripheral point of care, diagnostic for an example is absolutely crucial and should have a very high priority. We should not forget our systematic approach, this would be totally wrong."

"With regard to diseases of poverty, for a large majority of our world there is still not enough investment, because it is not profitable for companies. That is the sad situation. But companies may underestimate the value of a new point of care such as HIV resistance testing for instance. We treat thousands, even millions of people but we should monitor the behaviour of the virus and resistance development and we really need the technology to do this. Not in the university hospital but at the point of care where we have to ensure regular, continuous treatment."

"Companies do not realise, that although patients won´t buy these expensive drugs, nowadays there are large global initiatives that could buy or subsidize the development of treatments for diseases of poverty. Companies could actually get good returns on investment. This thinking has not yet sunk in."

"We can promote this thinking by getting it on the international agenda, bring it into the circles including the WHO (World Health Organisation), PDP (new Product Development Partnerships) or charities like the Bill & Melinda Gates Foundation. There are now many players for investments into health."

And what in your view will the field of health look like in 20 years?

"We will have an important moment in 2015 when we discuss whether we have achieved the millennium goals. I fear we will realize that in many countries we have not reached these goals because the systematic approach was or is lacking. If you have only the technological developments you will not really make big steps. You will have isolated wonderful solutions, but not the systematic approach that really will help improving health in a sustainable way."

And if we talk about biotechnological solutions, do you think there will be public debate about this?

"There must be a public debate about how sick our health systems are. You will see that technology has an important role to play in fixing health systems. But it is not just adding a little bit but really doing this in a comprehensive way. And not only with the people who invent technologies, but also with the users."

Do you have any other remarks that you like to add to this subject?

"My important point is that we have a fragmented approach to health and well being. We made good, secure steps, but never made progress in reducing inequalities in quality of life. Good health systems not only have medical components, but have equally strong social, cultural and economic components."

Coleen Vogel

7 April 2008
Subject: Global Change and Climate Change

Résumé

Coleen Vogel, Professor of Sustainability at the University of the Witwatersrand in South Africa and member of the South African Scientific Committee for Global Change.

What in your view are the most urgent problems in the field of climate change?

"First of all, we need to improve our knowledge of the global climate change systems (this includes Earth System science but also how we frame and interpret knowledge to better understand this complex system). Second, we need to gain more insight not only on what happens on a global scale, but also what the impacts are on a local scale. Moreover, I think the biggest challenge is that we sometimes focus only on the technological aspects of climate change, and not on the range of other interconnections that we could have with other people that could add value to the whole climate change problem. For example, for me it has been very interesting to see the shift to a more risk-reduction approach in the latest IPCC report, and not only to discuss the climate drivers and climate impacts. This results in a more proactive approach where the paradigms of other stakeholders are also taken into consideration."

"I notice that by maintaining a technocratic approach, much of the research is still focussed on emission mitigation. This is important but we also should focus on development and adaptation to climate change. This is what I mean by the phrase 'developing insights on a local scale."

How can we achieve this?

"We should not only communicate our knowledge, but also engage in dialogue. I therefore think that we should open up the community in the field of climate change so that not only meteorologists are working on the problem, but also, for example, scientists from anthropological and political sciences. For example, what does an agriculturalist need from a climate model? If you work in the energy domain, what else do you need besides renewable energy? We tend to look at this as scientists only: we produce our papers, maybe include them in the IPCC report and that's it. But we need to produce this knowledge in other ways, including a variety of perspectives, than we are currently doing, because we need it more and more quickly."

What are the necessary conditions for successful solutions?

"We need to conduct more research not only on how people are responding to climate change and future adaptations, but also how people respond to current adaptations. We need to have governments and other funders supporting good basic research by, for example, setting up integrated and comprehensive monitoring stations. Furthermore, we need more research involving multidisciplinary teams coming together to try to answer these questions. For example, I think it is a pity that we do not have more

behavioural psychologists and sociologists working on the problem, because then it would really be an issue around how can we live sustainably, given many constraints. Finally, we also need political will of course. Hence, it is important to have different levels of political engagement so that there is top-level support, as well as support at local municipal level. In order to achieve this, capacity is necessary. In Africa for instance, we are limited by our capacity not our ability. North-South and South-South partnerships need to be created where information and expertise is shared and exchanged, so that we can enhance our capacity and really work on mitigation and adaptation for climate change."

"I think there are a lot of people that would like to get involved, but just don´t know how to. For example the media, just look at what Al Gore has done to make climate change a real issue in peoples' lives."

Are there any biotechnological solutions for these problems?

"I think there are biotechnological solutions, such as GM food, but it should not just be limited to coming up with a solution 'made up in a laboratory'. It should be put in a wider context in order to tackle the problems. We have to be careful that we do not rush into things and create other problems. This includes looking at the political aspects, and research on who will benefit and who will suffer from the technology. Different stakeholders should therefore be included in discussions in the early stages when adopting new technologies. This should minimize the risk that we are creating new problems."

Should biotechnological solutions be placed higher on the social, political or scientific agendas? If so, why?

"Biotechnological solutions should be on the agenda, but clearly we have got other more urgent issues that also deserve attention like food accessibility and human security."

Which solutions might lead to public debate?

"Biotechnology is one issue on which people have different opinions. This could lead to public debate. Another issue is how we insure ourselves against risks, since the public will also be paying for this. The same is true for the security issues. My guess is that especially the issues that affect the people on a day to day basis will be in the newspapers and therefore in the public debate."

What are the differences between developing and developed countries (in terms of both problems and solutions)?

"In general the problems will be very much the same since floods and droughts can occur in all regions. But the impacts and the solutions will be different, based on how much capacity there is available. If a country is already in a vulnerable situation, it may need more resources to withstand impacts"

In your view, what will the field of climate change look like in 20 years time?

"Hopefully, if we do our homework now, the problems won't be too disastrous. I would like to think that, in 20 years time, we will have a society where, regardless of where you are, there is a natural system that can withstand the shocks and the stresses that may come with climate change. So I would like to hope that in 20 years time, we have changed our lifestyles enough that we are able to handle some of the things that may happen if we have climate change."

Which statement/question/dilemma would you like to put to the readers of this interview?

"I am quite interested in what the business community in various countries is doing around adaptation."

Appendix 2 - Statistics of the website

In the period from 9 April to 28 May 1058 visits were taken on the website, of which 659 were unique visitors. 61.72% of the visitors visited the site only once. On average they stayed on the website for 4 minutes and 1 second. 35.63% visited 1 page, 15.97% 2 pages, 11.44% 3 pages and 36.96% visited more than 3 pages.

The visitors originated from 64 countries. The top 10 of total visits (1058) is:

Country	**Visits**
Netherlands	427
United States	125
India	61
Belgium	43
Germany	36
France	36
Italy	31
United Kingdom	24
Switzerland	20
Australia	19

In the Netherlands, most of the visits originated from Woerden, Amsterdam, De Meern and Wageningen.

Most organisations that visited the website were AgBiotech companies, universities or governmental organisations. We did not make a comparison between the list of organisations we invited and the list of organisations that visited the site.